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EUROPE

NIGHT NOISE GUIDELINES FOR EUROPE

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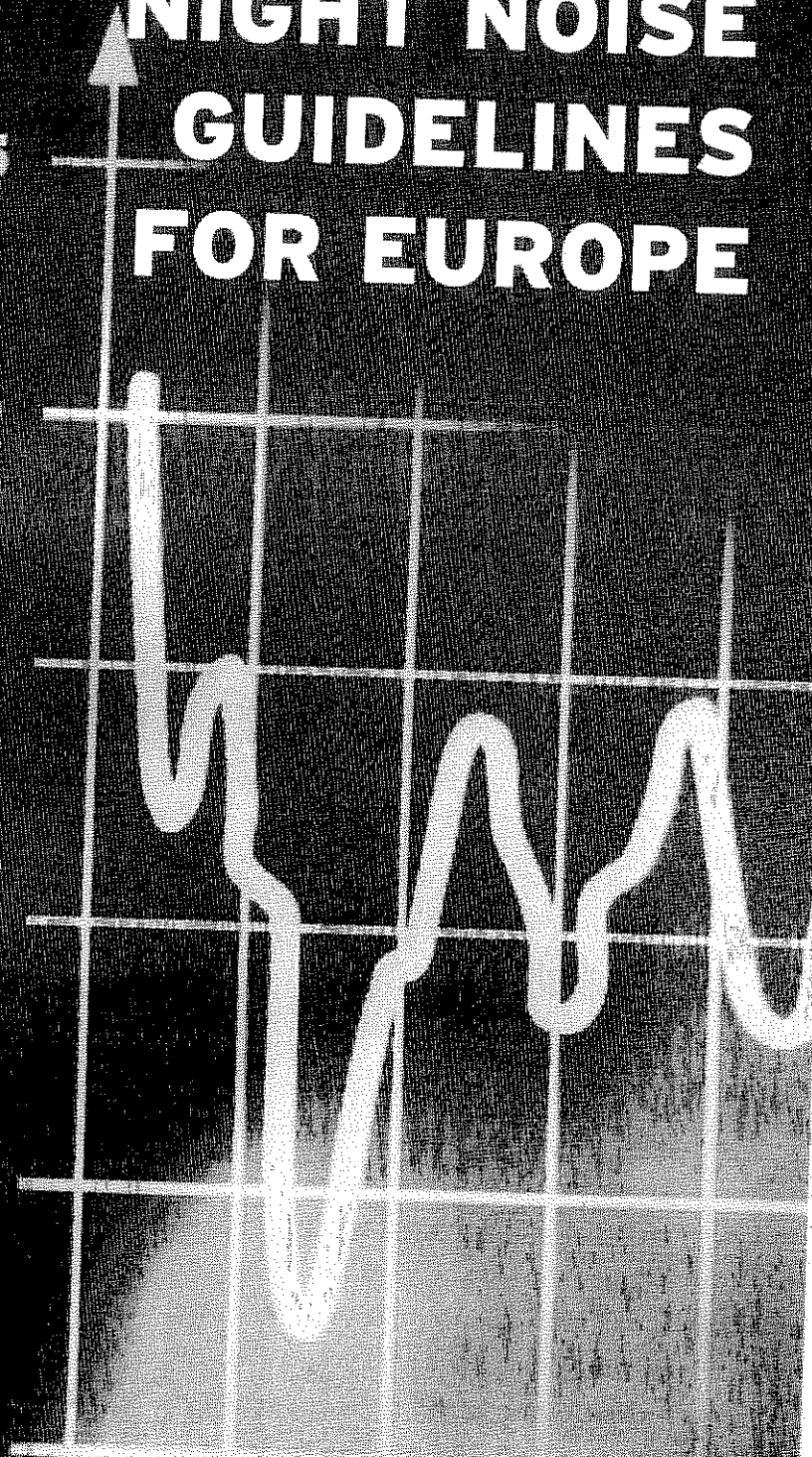
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NIGHT NOISE GUIDELINES FOR EUROPE

Keywords**NOISE - ADVERSE EFFECTS - PREVENTION AND CONTROL****SLEEP DEPRIVATION - ETIOLOGY****SLEEP DISORDERS - PREVENTION AND CONTROL****ENVIRONMENTAL HEALTH****HEALTH POLICY - LEGISLATION****GUIDELINES**

ISBN 978 92 890 4173 7

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Edited by Charlotte Hurlley, Layout by Dagmar Bengs

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ABSTRACT

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The WHO Regional Office for Europe set up a working group of experts to provide scientific advice to the Member States for the development of future legislation and policy action in the area of assessment and control of night noise exposure. The working group reviewed available scientific evidence on the health effects of night noise, and derived health-based guideline values. In December 2006, the working group and stakeholders from industry, government and nongovernmental organizations reviewed and reached general agreement on the guideline values and key texts for the final document of the *Night noise guidelines for Europe*.

Considering the scientific evidence on the thresholds of night noise exposure indicated by $L_{\text{night, outside}}$ as defined in the Environmental Noise Directive (2002/49/EC), an $L_{\text{night, outside}}$ of 40 dB should be the target of the night noise guideline (NNG) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly. $L_{\text{night, outside}}$ value of 55 dB is recommended as an interim target for the countries where the NNG cannot be achieved in the short term for various reasons, and where policy-makers choose to adopt a stepwise approach. These guidelines are applicable to the Member States of the European Region, and may be considered as an extension to, as well as an update of, the previous WHO *Guidelines for community noise* (1999).

FOREWORD

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WHO defines health as a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, and recognizes the enjoyment of the highest attainable standard of health as one of the fundamental rights of every human being. Environmental noise is a threat to public health, having negative impacts on human health and well-being. In order to support the efforts of the Member States in protecting the population's health from the harmful levels of noise, WHO issued *Guidelines for community noise* in 1999, which includes guideline values for community noise in various settings based on the scientific evidence available. The evidence on health impacts of night noise has been accumulated since then.

In the WHO European Region, environmental noise emerged as the leading environmental nuisance triggering one of the most common public complaints in many Member States. The European Union tackled the problem of environmental noise with an international law on the assessment and management of environmental noise. The WHO Regional Office for Europe developed the *Night noise guidelines for Europe* to provide expertise and scientific advice to the Member States in developing future legislations in the area of night noise exposure control and surveillance, with the support of the European Commission. This guidelines document reviews the health effects of night time noise exposure, examines exposure-effects relations, and presents guideline values of night noise exposure to prevent harmful effects of night noise in Europe. Although these guidelines are neither standards nor legally binding criteria, they are designed to offer guidance in reducing the health impacts of night noise based on expert evaluation of scientific evidence in Europe.

The review of scientific evidence and the derivation of guideline values were conducted by outstanding scientists. The contents of the document were peer reviewed and discussed for a consensus among the experts and the stakeholders from industry, government and nongovernmental organizations. We at WHO are thankful for those who contributed to the development and presentation of this guidelines and believe that this work will contribute to improving the health of the people in the Region.

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EXECUTIVE SUMMARY

INTRODUCTION

The aim of this document is to present the conclusions of the WHO working group responsible for preparing guidelines for exposure to noise during sleep. This document can be seen as an extension of the WHO *Guidelines for community noise* (1999). The need for "health-based" guidelines originated in part from the European Union Directive 2002/49/EC relating to the assessment and management of environmental noise (commonly known as the Environmental Noise Directive and abbreviated as END) which compels European Union Member States to produce noise maps and data about night exposure from mid-2007. The work was made possible by a grant from the European Commission and contributions from the Swiss and German governments.

Although a number of countries do have legislation directed at controlling night noise exposure, there is little information on actual exposure and its subsequent effects on the population. Estimates made in some countries of the number of people highly disturbed by noise during sleep (see Fig. 1 for the Netherlands as an example) indicate that a substantial part of the population could be exposed to levels that might risk their health and well-being.

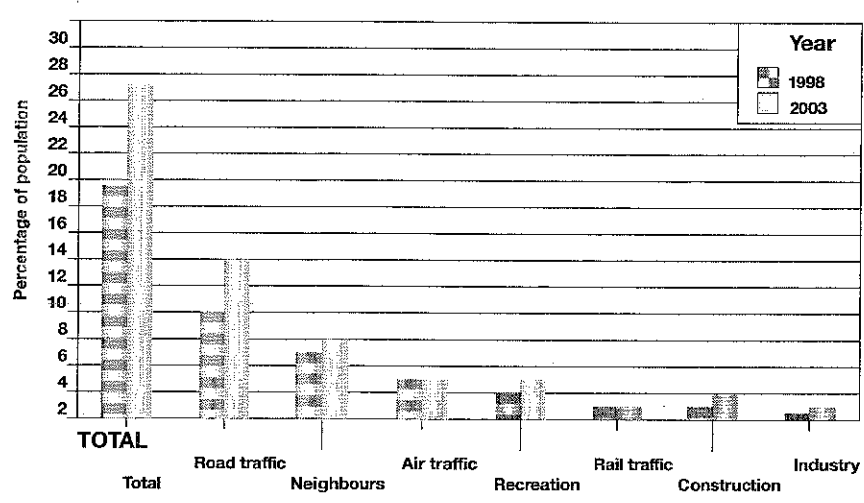


Fig. 1.
Percentage of population highly disturbed by noise during sleep in the Netherlands: survey results for 1998 and 2003

As direct evidence concerning the effects of night noise on health is rarely available, these guidelines also use indirect evidence: the effects of noise on sleep and the relations between sleep and health. The advantage of this approach is that a lot of medical evidence is available on the relation between sleep and health, and detailed information also exists on sleep disturbance by noise.

PROCESS OF DEVELOPING GUIDELINES

In 2003, the WHO Regional Office for Europe set up a working group of experts to provide scientific advice to the European Commission and to its Member States for the development of future legislation and policy action in the area of control and surveillance of night noise exposure. The review of available scientific evidence on the health effects of night noise was carried out by an interdisciplinary team who set out to derive health-based guideline values. The contributions from the experts were reviewed by the team and integrated into draft reports following discussion at four technical meetings of the working group. In 2006, all the draft reports were compiled into a draft document on guidelines for exposure to noise at night, which was reviewed and commented on by a number of stakeholders and experts.

At the final conference in Bonn, Germany, on 14 December 2006, representatives from the working group and stakeholders from industry, government and non-governmental organizations reviewed the contents of the draft document chapter by chapter, discussed several fundamental issues and reached general agreement on the guideline values and related texts to be presented as conclusions of the final WHO *Night noise guidelines for Europe*.

NOISE INDICATORS

From the scientific point of view the best criterion for choosing a noise indicator is its ability to predict an effect. Therefore, for different health end points, different indicators could be chosen. Long-term effects such as cardiovascular disorders are more correlated with indicators summarizing the acoustic situation over a long time period, such as yearly average of night noise level outside at the facade ($L_{\text{night, outside}}$), while instantaneous effects such as sleep disturbance are better with the maximum level per event (L_{Amax}), such as passage of a lorry, aeroplane or train.

From a practical point of view, indicators should be easy to explain to the public so that they can be understood intuitively. Indicators should be consistent with existing practices in the legislation to enable quick and easy application and enforcement. $L_{\text{night, outside}}$, adopted by the END, is an indicator of choice for both scientific and practical use. Among currently used indicators for regulatory purposes, L_{Aeq} (A-weighted equivalent sound pressure level) and L_{Amax} are useful to predict short-term or instantaneous health effects.

SLEEP TIME

Time use studies, such as that undertaken by the Centre for Time Use Research, 2006 (www.timeuse.org/access/), show that the average time adult people are in bed is around 7.5 hours, so the real average sleeping time is somewhat shorter. Due to personal factors like age and genetic make-up there is considerable variation in sleeping time and in beginning and end times. For these reasons, a fixed interval of 8 hours is a minimal choice for night protection.

Though results vary from one country to another, data show (see Fig. 2 as an example) that an 8-hour interval protects around 50% of the population and that it would take a period of 10 hours to protect 80%. On Sundays, sleeping time is consistently 1 hour longer, probably due to people recovering from sleep debt incurred during the week. It should also be borne in mind that (young) children have longer sleeping times.

¹ L_{night} is defined in the END as the outside level. In order to avoid any doubt, the suffix "outside" is added in this document.

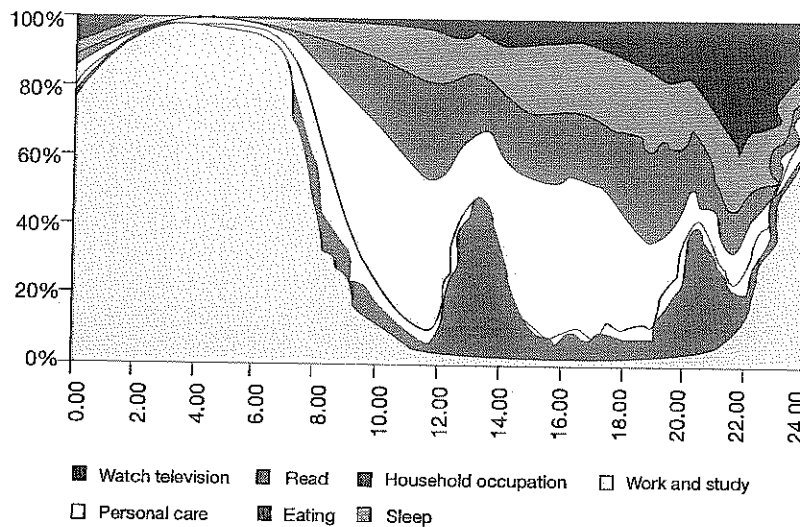


Fig. 2
Percentage of
time that the
Portuguese
population spend
asleep or in
different
activities

Source: <http://www.ine.pt/prodserve/destaque/arquivo.asp>,
based on a study by the Instituto Nacional de Estatística Portugal, 1999.

NOISE, SLEEP AND HEALTH

There is plenty of evidence that sleep is a biological necessity, and disturbed sleep is associated with a number of health problems. Studies of sleep disturbance in children and in shift workers clearly show the adverse effects.

Noise disturbs sleep by a number of direct and indirect pathways. Even at very low levels physiological reactions (increase in heart rate, body movements and arousals) can be reliably measured. Also, it was shown that awakening reactions are relatively rare, occurring at a much higher level than the physiological reactions.

DEFINITION OF "SUFFICIENT" AND "LIMITED" EVIDENCE

Sufficient evidence: A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could reasonably be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.

Limited evidence: A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes which lead to the adverse health effects.

The working group agreed that there is sufficient evidence that night noise is related to self-reported sleep disturbance, use of pharmaceuticals, self-reported health problems and insomnia-like symptoms. These effects can lead to a considerable burden of disease in the population. For other effects (hypertension, myocardial infarctions, depression and others), limited evidence was found: although the studies were few or not conclusive, a biologically plausible pathway could be constructed from the evidence.

An example of a health effect with limited evidence is myocardial infarction. Although evidence for increased risk of myocardial infarction related to L_{day} is sufficient according to an updated meta-analysis, the evidence in relation to $L_{\text{night, outside}}$ was considered limited. This is because $L_{\text{night, outside}}$ is a relatively new exposure indicator, and few field studies have focused on night noise when considering cardiovascular outcomes. Nevertheless, there is evidence from animal and human studies supporting a hypothesis that night noise exposure might be more strongly associated with cardiovascular effects than daytime exposure, highlighting the need for future epidemiological studies on this topic.

The review of available evidence leads to the following conclusions.

- Sleep is a biological necessity and disturbed sleep is associated with a number of adverse impacts on health.
- There is sufficient evidence for biological effects of noise during sleep: increase in heart rate, arousals, sleep stage changes and awakening.
- There is sufficient evidence that night noise exposure causes self-reported sleep disturbance, increase in medicine use, increase in body movements and (environmental) insomnia.
- While noise-induced sleep disturbance is viewed as a health problem in itself (environmental insomnia), it also leads to further consequences for health and well-being.
- There is limited evidence that disturbed sleep causes fatigue, accidents and reduced performance.
- There is limited evidence that noise at night causes hormone level changes and clinical conditions such as cardiovascular illness, depression and other mental illness. It should be stressed that a plausible biological model is available with sufficient evidence for the elements of the causal chain.

VULNERABLE GROUPS

Children have a higher awakening threshold than adults and therefore are often seen to be less sensitive to night noise. For other effects, however, children seem to be equally or more reactive than adults. As children also spend more time in bed they are exposed more to night noise levels. For these reasons children are considered a risk group.

Since with age the sleep structure becomes more fragmented, elderly people are more vulnerable to disturbance. This also happens in pregnant women and people with ill health, so they too are a group at risk.

Finally, shift workers are at risk because their sleep structure is under stress due to the adaptations of their circadian rhythm.

THRESHOLDS FOR OBSERVED EFFECTS

The no observed adverse effect level (NOAEL) is a concept from toxicology, and is defined as the greatest concentration which causes no detectable adverse alteration of morphology, functional capacity, growth, development or lifespan of the target organism. For the topic of night noise (where the adversity of effects is not always clear) this concept is less useful. Instead, the observed effect thresholds are provided: the level above which an effect starts to occur or shows itself to be dependent on the exposure level. It can also be a serious pathological effect, such as myocardial infarctions, or a changed physiological effect, such as increased body movement.

Threshold levels of noise exposure are important milestones in the process of evaluating the health consequences of environmental exposure. The threshold levels also delimit the study area, which may lead to a better insight into overall consequences. In Tables 1 and 2, all effects are summarized for which *sufficient and limited evidence* exists. For these effects, the threshold levels are usually well known, and for some the dose-effect relations over a range of exposures could also be established.

Effect	Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*
	EEG awakening	$L_{Amax,inside}$ 35
	Motility, onset of motility	$L_{Amax,inside}$ 32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{Amax,inside}$ 35
	Waking up in the night and/or too early in the morning	$L_{Amax,inside}$ 42
Sleep quality	Prolongation of the sleep inception period, difficulty getting to sleep	*
	Sleep fragmentation, reduced sleeping time	*
	Increased average motility when sleeping	$L_{night,outside}$ 42
Well-being	Self-reported sleep disturbance	$L_{night,outside}$ 42
	Use of somnifacient drugs and sedatives	$L_{night,outside}$ 40
Medical conditions	Environmental insomnia**	$L_{night,outside}$ 42

Table 1
Summary of effects and threshold levels for effects where *sufficient evidence* is available

* Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.

**Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.

Table 2
Summary of effects
and threshold levels
for effects where
limited evidence is
available**

Effect	Indicator	Estimated threshold, dB
Biological effects	Changes in (stress) hormone levels	*
Well-being	Drowsiness/tiredness during the day and evening	*
	Increased daytime irritability	*
	Impaired social contacts	*
	Complaints	$L_{night, outside}$ 35
	Impaired cognitive performance	*
Medical conditions	Insomnia	*
	Hypertension	$L_{night, outside}$ 50
	Obesity	*
	Depression (in women)	*
	Myocardial infarction	$L_{night, outside}$ 50
	Reduction in life expectancy (premature mortality)	*
	Psychic disorders	$L_{night, outside}$ 60
	(Occupational) accidents	*

* Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.

** Note that as the evidence for the effects in this table is limited, the threshold levels also have a limited weight. In general they are based on expert judgement of the evidence.

RELATIONS WITH $L_{NIGHT, OUTSIDE}$

Over the next few years, the END will require that night 'noise' exposures are reported in $L_{night, outside}$. It is, therefore, interesting to look into the relation between $L_{night, outside}$ and adverse health effects. The relation between the effects and $L_{night, outside}$ is, however, not straightforward. Short-term effects are mainly related to maximum levels per event inside the bedroom: $L_{Amax, inside}$. In order to express the (expected) effects in relation to the single European Union indicator, some calculation needs to be done. The calculation for the total number of effects from reaction data on events (arousals, body movements and awakenings) needs a number of assumptions. The first that needs to be made is independence: although there is evidence that the order of events of different loudness strongly influences the reactions, the calculation is nearly impossible to carry out if this is taken into consideration. Secondly, the reactions per event are known in relation to levels at the ear of the sleeper, so an assumption for an average insulation value must be made. In the report a value of 21 dB has been selected. This value is, however, subject to national and cultural differences. One thing that stands out is the desire of a large part of the population to sleep with windows (slightly) open. The relatively low value of 21 dB takes this into account already. If noise levels increase, people do indeed close their windows, but obviously reluctantly, as complaints about bad air then increase and sleep disturbance remains high. This was already pointed out in the WHO *Guidelines for community noise* (1999).

From source to source the number of separate events varies considerably. Road traffic noise is characterized by relatively low levels per event and high numbers, while air and rail traffic are characterized by high levels per event and low numbers. For two typical situations estimates have been made and presented in graphical form. The first is an average urban road (600 motor vehicles per night, which corresponds roughly to a 24-hour use of 8000 motor vehicles, or 3 million per year, the lower boundary the END sets) and the second case is for an average situation of air traffic exposure (8 flights per night, nearly 3000 per year).

Fig. 3 shows how effects increase with an increase of $L_{\text{night, outside}}$ values for the typical road traffic situation (urban road). A large number of events lead to high levels of awakening once the threshold of $L_{\text{Amax, inside}}$ is exceeded. To illustrate this in practical terms: values over 60 dB $L_{\text{night, outside}}$ occur at less than 5 metres from the centre of the road.

In Fig. 4 the same graph is presented for the typical airport situation. Due to a lower number of events there are fewer awakenings than in the road traffic case (Fig. 3), but the same or more health effects. In these examples the worst case figures can be factors higher: the maximum number of awakenings for an $L_{\text{night, outside}}$ of 60-65 dB is around 300 per year.

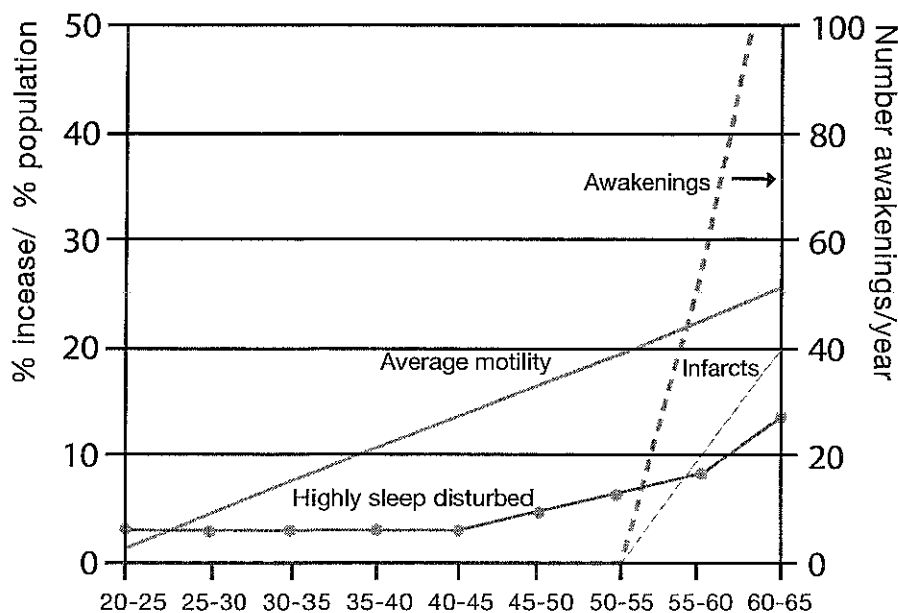


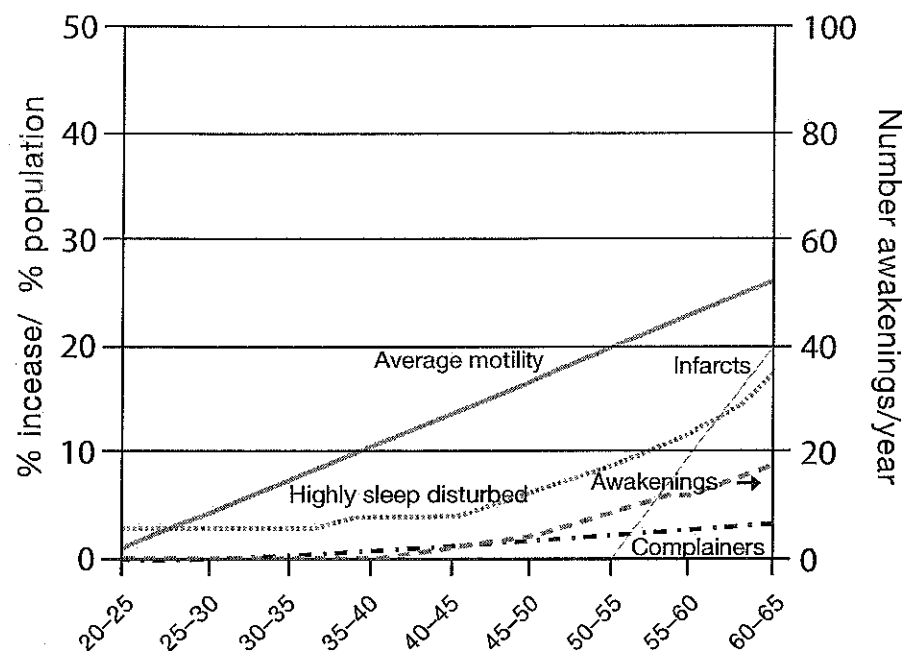
Fig. 3
Effects
of road traffic
noise at night*

*Average motility and infarcts are expressed in percent increase (compared to baseline number); the number of highly sleep disturbed people is expressed as a percent of the population; awakenings are expressed in number of additional awakenings per year.

A recent study suggests that high background levels of noise (from motorways) with a low number of separate events can cause high levels of average motility.

Therefore, by using the $L_{\text{night, outside}}$ as a single indicator, a relation between effects and indicator can be established. For some effects, however, the relation can be

Fig. 4
Effects of
aircraft noise
at night*



*Average motility and infarcts are expressed in percent increase (compared to baseline number); the number of highly sleep disturbed people is expressed as a percent of the population; complainers are expressed as a % of the neighbourhood population; awakenings are expressed in number of additional awakenings per year.

source dependent. Although L_{night} gives a good relation for most effects, there is a difference between sources for some. Train noise gives fewer awakenings, for instance. Once source is accounted for, the relations are reasonably accurate.

RECOMMENDATIONS FOR HEALTH PROTECTION

Based on the systematic review of evidence produced by epidemiological and experimental studies, the relationship between night noise exposure and health effects can be summarized as below. (Table 3)

Below the level of 30 dB $L_{\text{night, outside}}$, no effects on sleep are observed except for a slight increase in the frequency of body movements during sleep due to night noise. There is no sufficient evidence that the biological effects observed at the level below 40 dB $L_{\text{night, outside}}$ are harmful to health. However, adverse health effects are observed at the level above 40 dB $L_{\text{night, outside}}$, such as self-reported sleep disturbance, environmental insomnia, and increased use of somnifacient drugs and sedatives.

Therefore, 40 dB $L_{\text{night, outside}}$ is equivalent to the lowest observed adverse effect level (LOAEL) for night noise. Above 55 dB the cardiovascular effects become the major public health concern, which are likely to be less dependent on the nature of the noise. Closer examination of the precise impact will be necessary in the range between 30 dB and 55 dB as much will depend on the detailed circumstances of each case.

Average night noise
level over a year

$L_{\text{night, outside}}$

Health effects observed in the population

Up to 30 dB

Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{\text{night, outside}}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.

30 to 40 dB

A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{\text{night, outside}}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.

40 to 55 dB

Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.

Above 55 dB

The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

Table 3
Effects of different
levels of night noise
on the population's
health

A number of instantaneous effects are connected to threshold levels expressed in L_{Amax} . The health relevance of these effects cannot be easily established. It can be safely assumed, however, that an increase in the number of such events over the baseline may constitute a subclinical adverse health effect by itself leading to significant clinical health outcomes.

Based on the exposure-effects relationship summarized in Table 3, the night noise guideline values are recommended for the protection of public health from night noise as below.

Night noise guideline (NNG)
Interim target (IT)

$L_{\text{night, outside}} = 40 \text{ dB}$
 $L_{\text{night, outside}} = 55 \text{ dB}$

Table 4
Recommended night
noise guidelines
for Europe

¹ $L_{\text{night, outside}}$ is the night-time noise indicator (L_{night}) of Directive 2002/49/EC of 25 June 2002: the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year; in which: the night is eight hours (usually 23.00 – 07.00 local time), a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, the incident sound is considered, the assessment point is the same as for L_{den} . See *Official Journal of the European Communities*, 18.7.2002, for more details.

For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40 dB of $L_{\text{night, outside}}$ during the part of the night when most people are in bed. The LOAEL of night noise, 40 dB $L_{\text{night, outside}}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise.

An interim target (IT) of 55 dB $L_{\text{night, outside}}$ is recommended in the situations where the achievement of NNG is not feasible in the short run for various reasons. It should be emphasized that IT is not a health-based limit value by itself. Vulnerable groups cannot be protected at this level. Therefore, IT should be considered only as a feasibility-based intermediate target which can be temporarily considered by policy-makers for exceptional local situations.

RELATION WITH THE GUIDELINES FOR COMMUNITY NOISE (1999)

Impact of night-time exposure to noise and sleep disturbance is indeed covered in the 1999 guidelines, as below (WHO, 1999):

“If negative effects on sleep are to be avoided the equivalent sound pressure level should not exceed 30 dBA indoors for continuous noise. If the noise is not continuous, sleep disturbance correlates best with L_{Amax} and effects have been observed at 45 dB or less. This is particularly true if the background level is low. Noise events exceeding 45 dBA should therefore be limited if possible. For sensitive people an even lower limit would be preferred. It should be noted that it should be possible to sleep with a bedroom window slightly open (a reduction from outside to inside of 15 dB). To prevent sleep disturbances, one should thus consider the equivalent sound pressure level and the number and level of sound events. Mitigation targeted to the first part of the night is believed to be effective for the ability to fall asleep.”

The 1999 guidelines are based on studies carried out up to 1995 (and a few meta-analyses some years later). Important new studies (Passchier-Vermeer et al., 2002; Basner et al., 2004) have become available since then, together with new insights into normal and disturbed sleep. New information has made more precise assessment of exposure-effect relationship. The thresholds are now known to be lower than L_{Amax} of 45 dB for a number of effects. The last three sentences still stand: there are good reasons for people to sleep with their windows open, and to prevent sleep disturbances one should consider the equivalent sound pressure level and the number of sound events. The present guidelines allow responsible authorities and stakeholders to do this. Viewed in this way, the *night noise guidelines for Europe* are complementary to the 1999 guidelines. This means that the recommendations on government policy framework on noise management elaborated in the 1999 guidelines should be considered valid and relevant for the Member States to achieve the guideline values of this document.

CHAPTER 2

THE RELATION BETWEEN SLEEP AND HEALTH

A night of quiet and repose in the profound silence of Dingley Dell, and an hour's breathing of its fresh and fragrant air on the ensuing morning, completely recovered Mr Pickwick from the effects of his late fatigue of body and anxiety of mind.

(Charles Dickens, The Pickwick Papers, 1836)

2.1 SLEEP, NORMAL SLEEP, DEFINITIONS OF SLEEP DISTURBANCE, CHARACTERISTICS MECHANISMS, THE INSOMNIA MODEL

2.1.1 NORMAL SLEEP (OBJECTIVE MEASUREMENTS)

Sleep is part of living and, along with being awake, forms an inherent biological rhythm (Cooper, 1994). Normal sleep can be defined in an objective or subjective manner. The objective criteria are defined using a polysomnographic recording (PSG) of sleep, the method that measures different physiological functions during sleep. Minimal polygraphic requirements to measure sleep adequately include two channels of electroencephalography (EEG), one channel for the electrooculogram (EOG), and one channel for the submental electromyography (EMG). In routine PSG, additional channels are used to assess respiration, leg movements, oxygenation and cardiac rhythm (Ebersole and Pedley, 2003).

Scoring of sleep stages is usually done on an epoch-by-epoch basis, with a 30-second length used as a standard. Epochs are scored according to the guidelines of Rechtschaffen and Kales (1968). Each epoch is scored as the stage that occupies more than 50% of that epoch. Sleep can be divided into the following stages.

- Arousal is not a uniform concept and has been defined differently by different researchers. Commonly, the occurrence of alpha rhythms is required for EEG arousal. Depending on the additional requirements and on the length of time that the slower cortical rhythms are interrupted, arousals have been called, for instance, micro-arousal, minor arousal, EEG awakening or transient activation phases. The American Sleep Disorders Association (1992, 1997) devised a scoring system, taking sequences of 3–15 seconds into account for transient arousals which are not transferred to macroscopic behavioural awakening. Eleven further criteria must be met (see also Chapter 3, section 3.1.2).
- Vegetative arousals are activations of the sympathetic nervous system.
- Stage W corresponds to the waking stage and is characterized by alpha activity or low-voltage, mixed-frequency EEG activity. Rapid eye movements (REMs), eye blinks, and tonic EMG activity are usually present.
- Stage 1 is scored when more than 50% of an epoch is low-voltage, 2–7 Hertz (Hz) activity. Vertex waves may occur in late stage 1. Slow rolling eye movements lasting several seconds are routinely seen early in stage 1, but K complexes and sleep spindles are absent by definition. Tonic EMG activity is usually less than that of relaxed wakefulness.

- Stage 2 requires the presence of sleep spindles or K complexes, and less than 20% of the epoch contains delta activity. Bursts of sleep spindles must last at least 0.5 seconds before they can be scored. K complexes are defined as biphasic vertex sharp waves with a total duration of greater than 0.5 seconds.
- Stage 3 is scored when 20–50% of an epoch consists of delta activity that is 2 Hz or slower and is greater than 75 μ V in amplitude. Sleep spindles may or may not be present.
- Stage 4 is scored when more than 50% of an epoch consists of delta activity that is 2 Hz or slower and is more than 75 μ V in amplitude. Reliable differentiation of stage 3 and stage 4 sleep is difficult by visual inspection, and most laboratories combine stages 3 and 4 into a single determination of slow-wave sleep (SWS).
- Stage REM is characterized by relatively low-voltage, mixed-frequency EEG activity with episodic REMs and absent or markedly reduced axial EMG activity. Phasic EMG activity may occur, but tonic activity must be at a level that is as low as, or lower than, that during any other time in the study. Sleep spindles and K complexes are absent. Series of 2- to 5- Hz vertex-negative “saw-tooth waves” occur, particularly just before phasic REM activity. The requirements to score sleep as REM sleep are: REMs, low or absent axial EMG, and typical mixed-frequency EEG recording that does not preclude the scoring of REM.

Movement time is scored when more than 50% of an epoch is obscured by movement artefact. Movement time must be preceded or followed by sleep and is thus distinguished from movement occurring during wakefulness.

Additional sleep values are determined from each sleep study and contribute to the clinical interpretation of the study. These additional variables include the following.

- Recording time is the time elapsed between “lights out” and “lights on” at the end of the study.
- Total sleep time (TST) is the total time occupied by stage 1, stage 2, SWS and REM sleep.
- Sleep efficiency (SE) is defined as total sleep time divided by recording time and is expressed as a percentage.
- Sleep latency (SL) is the time from “lights off” to the first epoch scored as sleep. Some authors prefer to use the first epoch of stage 2 in order to be more confident about identifying the onset of sustained sleep. However, when sleep is very disrupted, there may be an extended interval from recognition of stage 1 until an epoch that can be scored as stage 2.
- REM latency is the time from sleep onset (as described earlier) to the first time period scored as REM, minus any intervening epochs as wakefulness.
- Sleep stage percentages (% in stage 1, stage 2, SWS and REM sleep) are determined by dividing time recorded in each sleep stage by total sleep time.
- Wake after sleep onset (WASO) is time spent awake after sleep onset.

The objective criteria defining normal sleep are based on: sleep latency, total sleep time, sleep efficiency and the number of awakenings, including cortical arousals. However, all these parameters are age-related, sometimes also gender-related, and may vary from one individual to another.

Normal sleep has a clearly defined architecture that is relatively stable. Predictable changes in sleep architecture occur with age. Beginning in middle age, SWS becomes less prominent, the number of awakenings increase, and sleep efficiency decreases. Published information on normal sleep can serve as an outline for normal values in PSG (Williams, Karacan and Hirsch, 1974; see also Table 2.1), but each laboratory must study control subjects to identify any significant effects on sleep that result from differences in technique or environment (Ebersole and Pedley, 2003).

Sleep parameter (normal values)	20–29 years	40–49 years	60–69 years
TST (min)	419	389	407
Sleep efficiency (TST/TIB ^a)	95%	91%	90%
WASO	1%	6%	8%
Stage 1 (% of TST)	4%	8%	10%
Stage 2 (% of TST)	46%	55%	57%
SWS (% of TST)	21%	8%	2%
REM (% of TST)	28%	23%	23%
Sleep latency (min)	15	10	8

Table 2.1
Average normal values for
adults of different ages

^a Time in bed

Source: Williams, Karacan and Hirsch, 1974.

Passchier-Vermeer (2003a) reports that subjects not exposed to loud night noise typically report waking up one and a half to two times during an average sleep period, while the number of EEG awakenings including cortical arousals averages 10–12 per night (Table 2.2).

Subjects not exposed to loud night noise	Subjective report of number of awakenings	Number of EEG awakenings
Normal adult subjects	1.5–2	10–12

Table 2.2
Parameters of normal
sleep

Source: Passchier-Vermeer, 2003a.

Night arousals result in fragmented sleep, which in turn leads to excessive daytime sleepiness (EDS). The gold standard for the assessment of EDS is the multiple sleep latency test (MSLT) (see Table 2.3), which provides an objective quantification of “sleepiness”. The preceding night’s sleep requires the PSG to ensure adequate sleep and to exclude sleep disruption. During the day, four or five nap times are scheduled every two hours. For each scheduled nap time the patient lies down and assumes a comfortable sleep position with the technician’s instructions to “close your eyes and attempt to sleep”. Each nap is terminated 20 minutes after the nap time started if no sleep occurred; or after 15 minutes of continuous sleep as long as sleep onset (SO) criteria are met before the end of 20 minutes; or after 20 minutes if the patient awakens, even if the patient has been asleep less than 15 minutes. The patient is instructed to stay awake between the nap periods.

		Group	MSLT (min)	No REM SO (% of group)	1 REM SO (% of group)	2 or more REM SO (% of group)
Table 2.3 Mean sleep latency	Narcoleptics		2.9 ± 2.7	2	2	96
	EDS (non-narcoleptic, non-sleep apnoeic)		8.7 ± 4.9	92	8	0
	Controls		13.4 ± 4.3	100	0	0

Source: Ebersole and Pedley, 2003.

2.1.2 DEFINITIONS OF DISTURBED SLEEP

Sleep disorders are described and classified in the International Classification of Sleep Disorders (ICSD) (American Academy of Sleep Medicine, 2005).

When sleep is permanently disturbed and becomes a sleep disorder, it is classified in the ICSD 2005 as “environmental sleep disorder”. Environmental sleep disorder (of which noise-induced sleep disturbance is an example) is a sleep disturbance due to a disturbing environmental factor that causes a complaint of either insomnia or daytime fatigue and somnolence. Secondary deficits may result, including deficits in concentration, attention and cognitive performance, reduced vigilance, daytime fatigue, malaise, depressed mood and irritability. The exact prevalence is not known. Fewer than 5% of patients seen at sleep disorder centres receive this diagnosis. The sex ratio is not known. The disorder may occur at any age, although the elderly are at more risk for developing this condition (American Academy of Sleep Medicine, 2005).

2.1.2.1 *Insomnia*

In the ICSD 2005 the section on insomnia includes a group of sleep disorders all of which have in common the complaint of insomnia (adjustment insomnia, psychophysiological insomnia, paradoxical insomnia, idiopathic insomnia, etc.), defined as repeated difficulty with sleep initiation, duration, consolidation or quality that occurs despite adequate time and opportunity for sleep and results in some form of daytime impairment. Insomnia is a symptom that often arises from primary medical illness, mental disorders and other sleep disorders, but may also arise from abuse or exposure. However, the general criteria for insomnia are the same for all subgroups of insomnias.

2.1.2.2 *General criteria for insomnia*

- A. A complaint is made concerning difficulty initiating sleep, difficulty maintaining sleep, waking up too early or sleep that is chronically non-restorative or poor in quality. In children, the sleep difficulty is often reported by the carer and may consist of observed bedtime resistance or inability to sleep independently.
- B. The above sleep difficulty occurs despite adequate opportunity and circumstances for sleep.
- C. At least one of the following forms of daytime impairment related to the nighttime sleep difficulty is reported by the patient:
 - fatigue or malaise
 - attention, concentration, or memory impairment
 - social or vocational dysfunction or poor school performance
 - mood disturbance or irritability

- daytime sleepiness
- motivation, energy, or initiative reduction
- proneness to errors or accidents at work or while driving
- tension, headaches, or gastrointestinal symptoms in response to sleep loss
- concerns or worries about sleep.

Defining the cause of a sleep/wake disturbance in an insomnia patient is a complex task since it is often multifactorial. In fact, a confluence of factors that support multiple insomnia diagnoses may be judged important in many patients with insomnia. Although selection of a single diagnosis is preferable and this selection may be appropriate, such a selection should not necessarily imply the absence of a subset of factors relevant to an alternate diagnosis. When criteria for multiple insomnia diagnosis are met, all relevant diagnosis should be assigned.

2.1.2.3 *Environmental sleep disorder*

In the ICSD 2005, environmental sleep disorder is listed in the category of "other sleep disorders". Noise-induced sleep disturbance is one of the disturbing environmental factors that cause a complaint of either insomnia or daytime fatigue and somnolence.

The diagnostic criteria for environmental sleep disorder are the following.

- A. The patient complains of insomnia, daytime fatigue or a parasomnia. In cases where daytime fatigue is present, the daytime fatigue may occur as a result of the accompanying insomnia or as a result of poor quality of nocturnal sleep.
- B. The complaint is temporally associated with the introduction of a physically measurable stimulus or environmental circumstance that disturbs sleep.
- C. It is the physical properties, rather than the psychological meaning of the environmental factor, that accounts for the complaint.
- D. The sleep disturbance is not better explained by another sleep disorder, medical or neurological disorder, mental disorder, medication use or substance use disorder.

The prevalence of environmental sleep disorder is not known. Fewer than 5% of patients seen at sleep disorder centres receive this diagnosis.

International standardization and quantification for measurement of the depth of sleep is based on Rechtschaffen and Kales criteria from 1968. Sleep is divided into 30-second epochs, and a phase is only assessed if the specific features are evident for more than 50% of the epoch length. For example, wakefulness is scored when at least 15 seconds of continuous awakening is present. Arousal reactions not leading to macroscopic awakening were not included in the definition by Rechtschaffen and Kales. With the arousals as described by the American Sleep Disorders Association (1992) it is possible to display sub-vigilant sleep fragmentation, caused by intrinsic sensory and autonomic alarm reactions. An arousal index providing the arousal density (events per hour of sleep) was taken as a measure of the degree of severity. In one hour, 10–20 arousals are considered as normal in healthy adults. However, the use of EEG arousals with the American Sleep Disorders Association definition provides no sufficient explanation of daytime sleepiness (Ali, Pitson and Stradling 1996; Ayas et al., 2001) unless they are accompanied by vegetative arousals.

Regarding noise, different vigilance level assessments in various functional systems are important. Dumont, Montplaisir and Infante-Rivard (1988) proposed investigations of

vegetative, motor and sensory functions independently of each other. One of the possible factors indicating disturbed sleep is a vegetative arousal index. A vegetative arousal index of more than 30 per hour is certainly considered as serious, more than 20 per hour as intermediate and more than 10 as a light form of sleep disorder.

With respect to insomnia (section 2.1.2), there is the possibility of misclassification if the general practitioner (GP) overlooks excessive noise as the possible cause of the complaint. There is also the possibility that the insomnia is aggravated by noise.

2.1.3 CONCLUSIONS

Published information on normal sleep can serve as an outline for normal values in PSG. However, these values are only informative, because each sleep laboratory must study control subjects to identify any significant effects on sleep that result from differences in technique or environment. Excessive daytime sleepiness is a consequence of disturbed night sleep and can be objectively assessed by MSLT, which provides an objective quantification of "sleepiness".

2.2 LONG-TERM HEALTH RISK MEDIATED BY SLEEP DISTURBANCES

2.2.1 STRESSORS, NEUROBEHAVIOURAL DATA AND FUNCTIONAL NEUROIMAGING

It is generally accepted that insufficient sleep and particularly sleep loss has a great influence on metabolic and endocrine functions (Spiegel, Leproult and van Cauter, 1999), as well as on inflammatory markers, and contributes to cardiovascular risk. C-reactive protein (CRP) as a major marker of the acute phase response to inflammatory reaction promotes secretion of inflammatory mediators by vascular endothelium and may be therefore directly involved in the development of atherosclerotic lesions. CRP as a risk predictor of strokes and heart attacks linearly increases with total and/or partial sleep loss (Meier-Ewert et al., 2004).

An additional factor, closely linked to cardiovascular health, glucose regulation and weight control, is leptin. Leptin is one of the major regulators of energy homeostasis and its circadian profile interacts closely with sleep.

Secretion of leptin increases at night and decreases during the day. A decreased leptin level, that is connected with sleep loss, increases appetite and predisposes to weight gain, impaired glucose tolerance and impaired host response.

Other studies have focused on how sleep loss affects neurobehavioural functions, especially neurocognitive performance. Functional brain imaging and EEG brain mapping studies show that the patterns of functional connectivity between brain regions, evident in the performance of specific cognitive tasks, are altered by sleep loss (NCSDR, 2003). According to this finding, the maintenance of sustained performance during sleep loss may depend upon regional functional plasticity.

Cumulative waking, neurocognitive deficits and instability of state that develop from chronic sleep loss have a basis in a neurobiological process that can integrate homeostatic pressure for sleep across days. Increased efforts have helped to determine the roles of REM and non-REM sleep in memory.

Functional brain imaging techniques, such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI), magnetic resonance spectroscopy (MRS), single photon emission computed tomography (SPECT) and magneto-electroencephalography (MEG), have recently been analysed in a study of sleep and waking (NCSDR, 2003). These techniques allow the measurement of metabolic and neurochemical activity throughout the brain, and can reveal dynamic patterns of regional cerebral activity during various brain states, including stages of sleep and levels of alertness during wakefulness or during functional challenge. These techniques can also help identify both normal and abnormal sleep/wake processes.

In the last five years, functional neuroimaging techniques (particularly PET) have revealed that non-REM sleep is associated with the deactivation of central encephalic regions (brainstem, thalamus, basal ganglia) and multimodal association cortices (for instance, prefrontal and superior temporal/inferior parietal regions). REM sleep is characterized by reactivation of all central encephalic regions deactivated during non-REM sleep except the multimodal association areas. PET studies during sleep-deprived wakefulness have revealed regional cerebral deactivations that are especially prominent in prefrontal and inferior parietal/superior temporal cortices, and in the thalamus. This pattern is consistent and helpful in explaining the nature of cognitive performance deficits that occur during sleep loss. As revealed by means of fMRI techniques during cognitive task performance, the maintenance of performance following sleep loss may be a function of the extent to which other cortical brain regions can be recruited for task performance in the sleep-deprived state.

PET, SPECT and fMRI studies have revealed, in depressed patients, initially elevated activation in anterior cingulate and medial orbital cortices (NCSDR, 2003). In these patients, sleep deprivation reduces this regional hyperactivation, and improvements in mood are a function of the extent to which this activity is reduced. These studies point to possible mechanisms by which antidepressant drugs may exert their effects. Further research should be oriented towards neuroimaging and measurements of changes in the brain's metabolic activity at the neurotransmitter level.

2.2.2 SIGNALS MEDIATED BY A SUBCORTICAL AREA (THE AMYGDALA), THE ROLE OF STRESS HORMONES IN SLEEP DISTURBANCE AND THEIR HEALTH CONSEQUENCES

Experimental as well as clinical studies (Waye et al., 2003; Ising and Kruppa, 2004) showed that the first and fastest signal of stressors introduced by noise is detected and mediated by a subcortical area represented by the amygdala while the stress response to noise is mediated primarily by the hypothalamus-pituitary-adrenal (HPA) axis. A major intrinsic marker of the circadian rhythm is in the level of circulating corticosteroids derived from activity within the HPA axis. A protracted stress response with activation of the HPA axis is a major physiological response to environmental stressors. The cortisol response to awakening is an index of adrenocortical activity, and long-term nocturnal noise exposures may lead, in persons liable to be stressed by noise, to permanently increased cortisol concentration above the nor-

mal range. The hypothesis that an increased risk of cardiovascular diseases is connected with stress concepts is generally accepted (Ekstedt, Åkerstedt and Soderstrom, 2004; Ising and Kruppa, 2004). Stress reactions may lead to derangement of normal neurovegetative and hormonal processes and influence vital body functions. Cardiovascular parameters such as BP, cardiac function, serum cholesterol, triglycerides, free fatty acids and haemostatic factors (fibrinogen) impede the blood flow through increased viscosity and presumably blood sugar concentration as well. Insulin resistance and diabetes mellitus, stress ulcers and immune system deficiency are also frequent consequences of stress reaction. Disturbed sleep may lead to immunosuppression and diminished protein synthesis (Horne, 1988).

As well as nonspecific effects of the stress response on the functioning of the immune system, there is considerable evidence for a relation between sleep, especially SWS, and the immune system (Brown, 1992). This evidence includes surges of certain immune parameters and growth hormones at onset of SWS, correlation of non-REM sleep, total sleep time and sleep efficiency with natural killer cell activity, and correlation of SWS with recovery from infections. These data, taken together with information on the effect of intermittent transportation noise on SWS during the first sleep cycles and overnight, suggest that the immune response could also be impacted directly by environmental noise during sleep (Carter, 1996).

2.2.3 SLEEP RESTRICTION, ENVIRONMENTAL STRESSORS (NOISE) AND BEHAVIOURAL, MEDICAL AND SOCIAL HEALTH CONSEQUENCES OF INSUFFICIENT SLEEP: RISK OF MORBIDITY AND MORTALITY

Sleep restriction due to environmental stressors leads to primary sleep disorders, but health is also influenced by the consequence of stress response to noise mediated by the HPA axis and/or by restriction of specific sleep stages (see above).

Sleep restriction leads, in approximately 40% of affected subjects, to daytime sleepiness that interferes with work and social functioning. Excessive daytime sleepiness is thus a major public health problem, as it interferes with daily activities, with consequences including cognitive problems, motor vehicle accidents (especially at night), poor job performance and reduced productivity (Lavie, Pillar and Malhotra, 2002). In the last decade, experimentally based data have been collected on chronic restriction of sleep (by 1–4 hours a night), accumulating daytime sleepiness and cognitive impairment. Most individuals develop cognitive deficits from chronic sleep debt after only a few nights of reduced sleep quality or quantity. New evidence suggests additional important health-related consequences of sleep debt related to common viral illnesses, diabetes, obesity, heart disease, depression and other age-related chronic disorders.

The effects and consequences of sleep deprivation are summarized in Table 2.4 (Lavie, Pillar and Malhotra, 2002).

The relationship between sleep quantity and quality and estimates of morbidity and mortality remains controversial. Epidemiological data (NCSDR, 2003) suggest that habitually short sleep (less than 6 hours sleep per night) is associated with increased mortality. Epidemiological studies in recent years elucidated, however, that too much sleep is a problem as well. Kripke et al. (2002) evaluated a questionnaire study of 1.1 million men and women aged 30–102 years and found the lowest mortality risk between respondents sleeping 7 hours per night.

Type	Short-term	Long-term
Behavioural	Sleepiness Mood changes Irritability and nervousness	Depression/mania Violence
Cognitive	Impairment of function	Difficulty in learning new skills Short-term memory problems Difficulty with complex tasks Slow reaction time
Neurological	Mild and quickly reversible effects	Cerebellar ataxia, nystagmus, tremor, ptosis, slurred speech, increased reflexes, increased sensitivity to pain
Biochemical	Increased metabolic rate Increased thyroid activity Insulin resistance	Decreased weight despite increased caloric intake (in animals) Diabetes, obesity (in humans)
Others	Hypothermia Immune function impairment	Susceptibility to viral illness

Table 2.4
Consequences of sleep deprivation

Mortality risk significantly increased when sleep duration was less than 6 or higher than 8 hours per night. Other authors have also published similar results (Patel et al., 2004; Tamakoshi and Ohno, 2004). Patel et al. (2004) in a prospective study of sleep duration and mortality risk in 5409 women confirmed previous findings that mortality risk is lowest among those sleeping 6–7 hours per night. The mortality risk for death from other causes significantly increased in women sleeping less than 5 and more than 9 hours per night. It is not clear how the length of sleep can increase this risk, although animal evidence points to a direct link between sleep time and lifespan (see section 2.5 in this chapter). Up to now, no epidemiological prospective study has been published that examines the relationship between sleep and health outcomes (morbidity and mortality) with subjective and objective estimates. Recent studies, however, show that sleep duration of least 8 hours is necessary for optimal performance and for prevention of daytime sleepiness and accumulation of sleep debt.

Environmental stressors, including noise, mostly cause insomnia. Insomnia also involves daytime consequences, such as tiredness, lack of energy, difficulty concentrating and irritability. A reasonable prevalence estimate for chronic insomnia in the general population is about 10%; for insomnia of any duration or severity this rises to between 30% and 50%, and incidence increases with ageing. In the course of perimenopausal time, women are particularly vulnerable to developing this complaint. The major consequences and co-morbidity of chronic insomnia (see Table 2.5) consist of behavioural, psychiatric and medical problems. Several studies also report a higher mortality risk (Zorick and Walsh, 2000).

Table 2.5
Consequences of
chronic insomnia

Type	Consequence
Behavioural	Poor performance at work, fatigue, memory difficulties, concentration problems, motor vehicle accidents
Psychiatric	Depression, anxiety conditions, alcohol and other substance abuse
Medical	Cardiovascular, respiratory, renal, gastrointestinal, musculoskeletal disorders Obesity Impaired immune system function
Mortality	Increased risk is reported

2.2.3.1 Behavioural consequences

Transient (short-term) insomnia is usually accompanied by spells of daytime sleepiness and performance impairment the next day. Persistent (long-term) insomnia tends to be associated with poor performance at work, fatigue, memory difficulties, concentration problems and twice as many fatigue-related motor vehicle accidents as in good sleepers.

2.2.3.2 Psychiatric conditions

Epidemiological research indicates that the prevalence of any psychiatric disorder is two or three times higher in insomniacs. The risk of depression as a co-morbid state appears to be particularly strong, being approximately four times more likely in insomnia patients. Furthermore, insomnia may be an early marker for psychiatric disorders such as depression, anxiety conditions and alcohol abuse. Anxiety has been quite commonly found in insomniacs compared with the general population. About 25–40% of insomnia patients are estimated to have significant anxiety, and the abuse of alcohol and other substances is increased in insomniacs relative to good sleepers (Ford and Kamerow, 1989). Samples of unselected psychiatric patients have about a threefold increase in the frequency of insomnia compared with healthy control subjects, and the severity of the condition correlates with the intensity of the psychiatric symptoms. Among samples of outpatients who consulted their GPs for insomnia, about 50% presented with psychiatric conditions, and about half of these patients were probably depressed (Zorick and Walsh, 2000).

2.2.3.3 Medical consequences

Insomnia has been statistically associated with various medical conditions, including disorders of the cardiovascular, respiratory, gastrointestinal, renal and musculoskeletal systems. A large series of insomniac patients showed that poor sleepers are more than twice as much at risk of ischaemic heart disease (IHD) as good sleepers (Hyypä and Kronholm, 1989). Insomnia patients were also shown (Irwin, Fortner and Clark, 1995) to have impaired immune system function. Keith et al. (2006) hypothesize a connection between sleep deficit as one of the possible factors to explain the rise in obesity. Hormone changes and animal experiments apparently support this.

2.2.3.4 Mortality risk

Only a few epidemiological studies deal with mortality in insomniacs. According to Kripke et al. (1979), reduced sleep time is a greater mortality risk than smoking, hypertension and cardiac disease. Higher death rates are also reported among short sleepers. In this respect, however, further systematic investigation of the link between insomnia, short sleep and death is desirable.

2.3 RISK GROUPS

Risk groups are people who may be either sensitive (showing more reaction to a stimulus than the average), are more exposed (also called vulnerable) or both.

2.3.1 HEALTH EFFECTS OF DISTURBED SLEEP IN CHILDREN

Although children appear to tolerate a single night of restricted sleep with no detrimental effect on performance of brief tasks, perhaps more prolonged restriction and prolonged tasks similar to those required in school would show negative effects. In addition, as children seem to require more time to recuperate fully from nocturnal sleep restriction than adults (Carskadon, Harvey and Dement, 1981a), with additional nights of partial sleep deprivation, cumulative sleepiness might become a significant problem.

Empirical data that directly address the effects of repeated sleep loss on children's mood or cognitive function are sparse. A range of clinical and observational data support a general picture that inadequate sleep results in tiredness, difficulties in focusing attention, low thresholds for negative reactions (irritability and easy frustration), as well as difficulty in controlling impulses and emotions. In some cases, these symptoms resemble attention-deficit hyperactivity disorder (ADHD).

Environmental noise experienced at home during night-time is a sometimes unpredictable and most often discontinuous event (for example traffic noise, aircraft or train noise; a noisy environment for other reasons, for instance proximity with a discotheque, etc.), that might lead to sleep disruption without leading to behavioural awakenings through the alteration of sleep microstructure, in a similar manner as other sleep disturbing events such as respiratory disturbances.

Therefore, in respect of clinical settings, we can assume that, in children, an experimental model for the consequences of noise can be represented by respiratory disturbances during sleep, such as snoring, upper airway resistance syndrome (UARS) or obstructive sleep apnoea syndrome (OSAS), either for the noise produced by snoring or for the effects on the arousal system and sleep microstructure.

For this reason, this section describes the well-studied effects of sleep breathing disorders on children's health and then evaluates the indicators of sleep disruption from the point of view of sleep microstructure.

In the literature few data on the medium- and long-term effects of disturbed sleep in children are available from the longitudinal point of view. Most reports focused on respiratory disturbances during sleep as a theoretical model to evaluate the long-term effects of disturbed sleep in children. This review reports on the medium- and long-term negative consequences of disturbed sleep on cognitive functioning, behaviour, mental health, growth and the cardiovascular system.

2.3.1.1 *Sleep deprivation in children*

The effects of sleep deprivation were evaluated in children. The findings only indirectly pertain to this general report, although repeated noise-induced sleep disruption favours sleep deprivation.

In another study, 15 healthy infants aged 78 \pm 7 days were studied during two nights: one night was preceded by sleep deprivation (kept awake for as long as pos-

sible beyond their habitual bedtime: median onset 150 min; range 0–210 min) (Thomas et al., 1996). Of the 15 children, 13 slept supine, 12 were breastfed and 4 were from smoking parents. Following sleep deprivation, infants maintained a greater proportion of quiet sleep (44% vs. 39%; $p=.002$). There was no measurable change in arousal propensity by either graded photic (stroboscope) or auditory stimuli (1 kHz pure tone, delivered in the midline of the cot, from 73 dB and increased in 3 dB steps to 100 dB) during quiet sleep.

Forty-nine Finnish children (26 boys/23 girls) aged 7–12 years were interviewed together with their parents and school teachers, and recorded for 72 hours with a belt-worn activity monitor during weekdays.

The objectively measured true sleep time was associated with psychiatric symptoms reported by a teacher. The decreased amount of sleep was associated more with externalizing than internalizing types of symptoms (aggressive and delinquent behaviour, attention, social, and somatic problems) (Aronen et al., 2000).

In a survey, it was also shown that out of 100 Belgian school children, aged between 9 and 12 years, those with poor sleep (insomnia) were also showing more frequent poor school performance (failure to comply with expected grades) than good sleepers. The relation between poor sleep and a noisy environment was, however, not evaluated (Kahn et al., 1989).

2.3.1.2 *Neurocognitive manifestations*

Several studies in adults have shown that sleep fragmentation and hypoxaemia can result in daytime tiredness and loss of concentration, retrograde amnesia, disorientation, morning confusion, aggression, irritability, anxiety attacks and depression. One could hypothesize that sleep fragmentation and hypoxaemia would affect the neuropsychological and cognitive performance also in children, where the impact of abnormal sleep may be even greater than in adults. In fact, neurocognitive and behavioural deficits and school problems have been reported recently in children with sleep-related obstructive breathing disorders (SROBD).

2.3.1.3 *Attention capacity*

This represents the ability to remain focused on a task and appropriately attend to stimuli in the environment. Taken together the studies to date indicate that children with SROBD are less reflective, more impulsive, and show poorer sustained and selective attention. Blunden et al. (2000) reported that, compared to 16 controls, 16 children with mild SROBD showed reduced selective and sustained attention. Owens-Stively et al. (1997) suggested a dose-response in attention-impulsivity with moderate to severe obstructive sleep apnoea syndrome (OSAS) children showing greater deficits than mild OSAS children. Importantly, early treatment showed that attention deficits in children with OSAS are reversible (Guilleminault et al., 1982b). In another study, 12 children with moderate to severe OSAS showed a significant reduction in inattention and an improvement in aggressive and hyperactive behaviours and vigilance after surgical treatment (Ali, Pitson and Stradling, 1996).

2.3.1.4 *Memory*

Rhodes et al. (1995) found inverse correlations between memory and learning performance and the apnoea hypopnea index in 14 morbidly obese children. Smaller deficits were observed by Blunden et al. (2000), who found in their sample of children with mild SROBD that mean global memory performance was in the lower end of the normal range compared to controls.

A recent study using actigraphy in normal school-age children showed that lower sleep efficiency and longer sleep latency were associated with a higher percentage of incorrect responses in working memory tasks; shorter sleep duration was associated with performing tasks at the highest load level only. Also, controlling for age, gender, and socioeconomic status, sleep efficiency and latency were significantly associated with the mean incorrect response rate in auditory working memory tasks. This study showed that sleep quality (evaluated as $\text{sleep efficiency} = 100 \times [\text{sleep} + \text{light sleep}] / \text{duration}$) is more strongly associated with performance in working memory tasks than sleep duration, suggesting that in assessing sleep, attention should be directed not only at the amount of sleep but also at sleep quality.

2.3.1.5 *Intelligence*

Inspection of the mean IQ scores reported in the study by Rhodes et al. (1995) suggested that their sample of five obese children with moderate to severe OSAS performed in the borderline range whereas controls performed in the normal range. Blunden et al. (2000) showed smaller deficits in children with mild SROBD whose mean verbal and global IQ were in the lower end of the normal range.

It remains unclear as to whether the putative negative effects of SROBD on intelligence are global in nature or confined to specific areas such as verbal rather than performance or visuospatial intelligence and whether these impairments can be reversed.

2.3.1.6 *Learning and school performance*

It has been widely reported (Stradling et al., 1990; Guilleminault et al., 1996; Richards and Ferdman, 2000) that children with SROBD show reduced academic performance and learning.

Weissbluth et al. (1983) found that poor academic achievers had a higher prevalence of night-time snoring (38% vs. 21%) and breathing difficulties (13% vs. 6%). Out of 297 children with SROBD (22% snorers and 18% sleep-associated gas exchange abnormalities), 40% were in the lowest 10th percentile of academic performance (Gozal, 1998) and SROBD in early childhood may continue to adversely affect learning in later years (Gozal and Pope, 2001). Gozal (1998) found in his sample of poor academic achievers that school grades improved post-adenotonsillectomy in treated but not untreated children.

As well as those with SROBD, healthy normal children with fragmented sleep (measured by actigraphy) also showed lower performance on neurobehavioural functioning (NBF) measures, particularly those associated with more complex tasks, and also had higher rates of behavioural problems (Sadeh, Gruber and Raviv, 2002). Furthermore, in normal children without sleep disorders, modest sleep restriction can also affect children's NBF. Sadeh, Gruber and Raviv (2003) monitored 77 children for 5 nights with activity monitors. On the third evening, the children were asked to extend or restrict their sleep by an hour on the following three nights. Their NBF was reassessed on the sixth day following the experimental sleep manipulation and showed that sleep restriction led to improved sleep quality and to reduced reported alertness.

These studies suggest that fragmented sleep or insufficient sleep is highly relevant during childhood and that children are sensitive to modest alterations in their natural sleep duration.

Early reports documented that untreated OSAS can have long-term negative effects, such as failure to thrive, cor pulmonale and mental retardation. These severe consequences are less common now due to early diagnosis and treatment, but recent reports have focused on other long-term effects mainly related to neurocognitive deficits, such as poor learning, behavioural problems and ADHD (Marcus, 2001).

Gozal and Pope (2001) tried to determine the potential long-term impact of early childhood snoring. Analysing questionnaires of 797 children in a low academic performance group (LP) and 791 in a high academic performance (HP) group, they found that frequent and loud snoring during early childhood was reported in 103 LP children (12.9%) compared with 40 HP children (5.1%). Therefore, children with lower academic performance in middle school are more likely to have snored during early childhood and to require surgery for snoring compared with better performing schoolmates. These findings suggest that children who experienced sleep-disordered breathing during a period traditionally associated with major brain growth and substantial acquisition of cognitive and intellectual capabilities may suffer from a partially irreversible compromise of their *a priori* potential for academic achievement. Three major components that result from the intermittent upper airway obstruction that occurs during sleep in children could theoretically contribute to such neurocognitive deficits, namely episodic hypoxia, repeated arousal leading to sleep fragmentation and sleep deprivation, and periodic or continuous alveolar hypoventilation.

Schooling problems may underlie more extensive behavioural disturbances such as restlessness, aggressive behaviour, EDS and poor neurocognitive test performances. Nearly 20–30% of children affected by OSAS or loud and frequent snoring show important signs of behavioural problems such as inattention and hyperactivity. Problems similar to symptoms of ADHD are linked to the presence of repeated sleep arousals, and intermittent hypoxic events, inducing a lack of behavioural inhibition with negative implications for working memory, motor control and self-regulation of motivation and affect.

In contrast with these data, Engle-Friedman et al. (2003) recently found a significant improvement of functions, at least in mild to moderate OSAS, when measured several months following an adenotonsillectomy, but they confirmed that their results could not rule out the possibility, even after treatment, of partial irreversible damage to academic function that may be detected only later in life. In addition, they stated that adults who also had deficits of neurocognitive executive functions related to the prefrontal area failed to improve significantly after treatment.

The negative long-term effects may be mediated by the irreversible alteration of the prefrontal cortex (PFC) and be related to structural changes of the brain as a consequence of both hypoxaemia and sleep fragmentation induced by OSAS or other pathologies affecting sleep.

In a recent report concerning OSAS adults, Macey et al. (2002) demonstrated grey matter loss in cerebral sites involved in motor regulation of the upper airway as well as in areas contributing to cognitive function (frontal and parietal cortex, temporal lobe, anterior cingulate, hippocampus and cerebellum). It can be argued that, in critical stages of brain development (that is, in childhood), these effects can lead to even more severe consequences, which could explain the negative long-term effects.

It is speculative to think that the remodelling of the brain could also be mediated by sleep and, therefore, sleep fragmentation could affect the process of brain plasticity (that is, the capacity of the brain to modify its structure and function over time). Recent studies show-

ing experience-dependent gene-expression of gene *zif-268* during paradoxical sleep in rats exposed to a rich sensorimotor environment, and the role of sleep in enhancing the remodelling of ocular dominance in the developing visual cortex are also in line with the hypothesis that sleep affects neuronal plasticity and memory processes (Peigneux et al., 2001).

2.3.1.7 Neurobehavioural manifestations

Behavioural disturbances are common in children with SRODB, with higher prevalence rates of both internalized (for instance being withdrawn, shy, anxious and psychosomatic) and externalized (for instance impulsivity, hyperactivity, aggression and delinquency) problematic behaviours (Blunden, Lushington and Kennedy, 2001). The most frequently documented problematic behaviour in children with SROBD is attention deficit hyperactivity with a prevalence rate of 20–40% (Weissbluth et al., 1983; Ali, Pitson and Stradling, 1993). Conversely, children with ADHD showed a high prevalence rate of snoring (Chervin et al., 1997) and a co-diagnosis of ADHD has been reported in 8–12% of children with OSAS (O'Brien and Gozal, 2002).

A few studies have documented that children with sleep disorders tend to have behavioural problems similar to those observed in children with ADHD. A survey of 782 children documented daytime sleepiness, hyperactivity, and aggressive behaviour in children who snored, with 27% and 38% of children at high risk for a sleep or breathing disorder displaying clinically significant levels of inattention and hyperactive behaviour, respectively (Ali, Pitson and Stradling, 1994).

At 3 years of age children with persistent sleep problems ($n = 308$) were more likely to have behaviour problems, especially tantrums and behaviour management problems (Zuckerman, Stevenson and Bailey, 1987).

In a study of 16 children with a mean age of 12 ± 4 years suffering from chronic pain due to juvenile rheumatoid arthritis and secondary poor sleep, polysomnographic recordings showed poorer night-time sleep, longer afternoon naptime and more daytime sleepiness than normal values from the literature (Zamir et al., 1998). In a school survey of children aged 9–12 years ($n = 1000$), those with poor sleep (insomnia for more than 6 months) had poorer school performance, defined as failure to comply with expected grades, than good sleepers. Their learning problems were tentatively attributed to the long-term effect of poor sleep (Kahn et al., 1989).

A questionnaire administered to children aged 4–12 years ($n = 472$) showed a relation between sleep problems and tiredness during the day (Stein et al., 2001).

In children aged 9–12 years ($n = 77$), shortening sleep by one hour was associated with reduced alertness and significant lowering of neurobehavioural functioning (Sadeh, Gruber and Raviv, 2003). In school-age children ($n = 140$) recorded at home with an actigraph, a significant relation was shown between the presences of fragmented sleep, daytime sleepiness and lower performance in neurobehavioural functioning evaluated by various performance tests (Sadeh, Gruber and Raviv, 2000). These children also had higher rates of behavioural problems, as reported by their parents (Sadeh, Gruber and Raviv, 2002).

In Finland, children aged 7–12 years ($n = 49$) were interviewed together with their parents and schoolteachers and recorded for 72 hours with a belt-worn activity monitor during weekdays. The decreased amount of sleep was associated with symptoms such as aggressive and delinquent behaviour, attention, social and somatic problems. The findings of this research were better associated with the teachers' than the par-

ents' reports, suggesting that parents may be unaware of their child's sleep deficiencies as the behavioural problems may be more evident at school than at home (Aronen et al., 2000).

A prospective long-term study conducted in Sweden on 2518 children revealed that within a subgroup of 27 children with severe and chronic sleep problems, 7 children developed symptoms that met the criteria for ADHD by the age of 5.5 years (Thunström, 2002). Compared to the other children with sleep problems, these subjects had more frequent psychosocial problems in the family, bedtime struggles and long sleep latency at bedtime.

A population-based, cross-sectional questionnaire survey was conducted in Massachusetts on 30 195 children aged 5 years (Gottlieb et al., 2003). Children described by their parents as having sleep-disordered breathing (snoring, noisy breathing, apnoea) were significantly more likely to have daytime sleepiness and problem behaviours, including hyperactivity, inattention and aggressiveness (all with an odds ratio >2.0). These problem behaviours were suggestive of ADHD.

Similar findings were found in a group of children aged 5–7 years with periodic limb movement disorder who were studied polygraphically and their recording compared with those of age-matched children with ADHD. Their repeated sleep fragmentation resulting from the periodic limb movement disorder favoured the development of symptoms similar to those seen in ADHD (Crabtree et al., 2003).

The parents of a group of children with an average age of 8.6 years (range 2–17 years) reported that their children had difficult behaviours on the day that followed a 4-hour night-time sleep restriction (Wassmer et al., 1999). In one study, a 2-hour sleep reduction induced by delayed bedtime has been shown to increase daytime sleepiness, mainly during morning hours (Ishihara and Miyke, 1998; Ishihara, 1999).

Following one night of 4 hours of sleep deprivation imposed on children (aged 11–13 years), a decrease in performance tests has been observed (Carskadon, Harvey and Dement, 1981a).

Following one night's sleep loss, adolescents showed increased sleepiness, fatigue and reaction time. They selected less difficult academic tasks during a set of tests, but the percentages of correct responses were comparable to those seen following a normal night's sleep (Engle-Friedman et al., 2003).

Another study has been conducted on 82 children, aged 8–15 years. They were assigned an optimized, 10-hour night of sleep, or a restricted 4-hour night of sleep. Sleep restriction was associated with shorter daytime sleep latency, increased subjective sleepiness, and increased sleepy and inattentive behaviours, but was not associated with increased hyperactive-impulsive behaviour or impaired performance in tests of response inhibition and sustained attention (Fallone et al., 2001).

2.3.1.8 *Mental health*

A recent longitudinal study on the outcomes of early life sleep problems and their relation to behaviour problems in early childhood stressed the importance of studying the natural history of sleep problems and their consequences in order to identify whether persistent or recurrent sleep problems at age 3–4 years are associated with co-morbidities such as child behaviour problems, maternal depression and poor family functioning (Peiyoong, Hiscock and Wake, 2003).

The authors found that night waking at 3–4 years of age continued to be common. Seventy eight percent of mothers reported that their child awoke during the night at least once during the week, and of these waking children, 43% were reported to have awakenings 4 or more nights per week. Children with early sleep problems had significantly higher mean scores on internalizing and externalizing behaviour and the aggressive behaviour and somatic problems subscales of the Child Behavior Checklist (CBCL).

It has been noted that within groups of children and adolescents with psychiatric, behavioural or emotional problems, rates of sleep disorders are elevated (Sadeh et al., 1995). On the other hand, children and adolescents with disturbed sleep report more depression, anxiety, irritability, fearfulness, anger, tenseness, emotional instability, inattention and conduct problems, drug use and alcohol use.

Only a few longitudinal studies in adolescents have evaluated the impact of insomnia on future functioning. In a large sample of 11–17-year-old adolescents, followed for one year, using symptoms of DSM-IV criteria for insomnia, Roberts, Roberts and Chen (2002) found that nearly 18% of the youths 11–17 years of age reported non-restorative sleep almost every day in the past month, over 6% reported difficulty in initiating sleep, over 5% waking up frequently during the night, another 3% had early-morning awakening almost every day, over 7% reported daytime fatigue and 5% daytime sleepiness. Combining “often” and “almost every day” response categories dramatically increases prevalence, ranging from 60% for non-restorative sleep to 23% for daytime fatigue and 12% for waking up at night with difficulty going back to sleep. The re-evaluation of the sample at follow-up showed that insomnia predicted two indicators of psychological functioning: self-esteem and symptoms of depression (Roberts, Roberts and Chen, 2002).

2.3.1.9 Growth impairment

Failure to thrive is a well-known complication of disturbed sleep and childhood OSAS. The cause of poor growth is not known, although many different reasons have been implicated: (a) poor caloric intake associated with adenotonsillar hypertrophy; (b) excessive caloric expenditure secondary to increased work of breathing; (c) abnormal growth hormone (GH) release secondary to loss of deep non-REM sleep. The relative roles of these factors are unclear (Marcus et al., 1994; ATS, 1999). Circulating concentrations of insulin-like growth factor-I (IGF-I) and IGF-binding protein 3 (IGFBP-3) reflect mean daily GH levels, and seem to correlate well with physiological changes in GH secretion. In the operated children with initial OSAS a highly significant reduction in the apnoea-hypopnea index (AHI) was found and both the IGF-I and the IGFBP-3 concentrations increased significantly. GH is released in a pulsatile fashion; the initial secretion is synchronized with the onset of SWS and strongly correlated with slow-wave activity, within 90 to 120 minutes from the onset of sleep (Nieminen et al., 2002). In OSAS children, the sleep architecture is relatively well-preserved, but the microstructural alteration of SWS due to micro-arousals induced by respiratory disturbance could play a role in the abnormal profile of GH secretion.

2.3.1.10 Cardiovascular complications

Children with OSAS had a significantly higher diastolic blood pressure (BP) than those with primary snoring. Multiple linear regression showed that BP could be predicted by apnoea index, body mass index and age. The aetiology of OSAS-related hypertension is thought to be due to a number of factors, particularly sympathetic nervous system activation secondary to arousal and, to a lesser degree, hypoxaemia.

Although cortical arousals at the termination of obstructive apnoeas are less common in children than in adults, children may manifest signs of subcortical arousal, including autonomic changes such as tachycardia. It is therefore possible that these subcortical arousals are associated with elevations of BP. A correlation between the frequency of obstructive apnoea and BP, but no correlation between SaO₂ (arterial oxygen saturation) and BP was found, suggesting that respiratory-related subcortical arousals rather than hypoxaemia may be a major determinant of BP elevation in children (Marcus, Greene and Carroll, 1998). Similarly to BP variations induced by OSAS, other studies suggest that chronic exposure to environmental noise during sleep could contribute to a permanent increases in BP in otherwise healthy individuals and that no habituation to noise was apparent over three consecutive sleep sessions (Carter et al., 2002). This is further elaborated in Chapter 4, section 4.5.

2.3.1.11 Risk of accidents

Only one study was found that evaluated the association between sleep and duration of wakefulness and childhood unintentional injury (Valent, Brusaferrro and Barbone, 2001).

Two hundred and ninety-two injured children who attended the Children's Emergency Centre in Udine, Italy, or their parents were interviewed following a structured questionnaire. The sleeping time and wakefulness of the child was assessed retrospectively for each of the 48 hours before injury. For each child, the authors compared the 24 hours immediately before the injury (hours 1–24; case period) with hours 25–48 (control period).

Overall, more children had longer hours of sleep during the control period than during the case period. A direct association between injury risk and sleeping less than 10 hours was found among boys (RR: 2.33; 95% CI: 1.07–5.09) but not among girls (RR: 1.00; 95% CI: .29–3.45). The study also found a direct association between injury occurring between 16.00 and midnight, and being awake for at least 8 hours before injury occurred (both sexes, RR: 4.00; 95% CI: 1.13–14.17). Sleeping less than 10 hours a day was associated with an 86% increase in injury risk. A significantly increased risk did not emerge in all subgroups of patients but it was evident among children aged 3–5 years, boys in particular. A fourfold increase in injury risk was also associated with being awake for at least 8 hours among males only. These findings demonstrated that inadequate sleep duration and lack of daytime naps are transient exposures that may increase the risk of injury among children. Results of a study on sleep disturbance and injury risk in young children show inadequate sleep duration and lack of daytime naps. A lack of daytime naps means transient exposures that may increase the risk of injury among children. Among children (boys in particular) aged 3–5 years, sleeping less than 10 hours a day was associated with an 86% increase in injury risk. A fourfold increase in injury risk was also associated with being awake for at least 8 hours.

Daytime sleepiness in children is often manifested by externalizing behaviours noted by parents or teachers, such as increased activity levels, aggression, impulsivity, as well as by poor concentration, instantiation irritability and moodiness (Fallone, Owens and Deane, 2002).

Analysing attendance at school, data show that accidents took place at school (25.6%) and at home (22.0%), and statistics show that there is a highly significant greater total accident rate among boys than among girls. The most frequent injuries happening at school are fractures and dislocation of joints, head injuries being more common among school injuries compared with spare-time injuries. Most injuries

occurred when children were in sports areas and it is noteworthy that 25% of all injuries were caused through intentional violence by other pupils.

2.3.1.12 Use of sleeping pills

Several studies demonstrated that the use of sleeping pills is common among children and that paediatricians are prone to prescribe these medications. Twenty-five percent of firstborn infants had been given "sedatives" by 18 months (Ounsted and Hendrick, 1977). A research study into parental reports of 11 000 preschool children showed that 12% took psychoactive drugs, most commonly for sleep: 39% daily and 60% intermittently for 1–2 years (Kopferschmitt et al., 1992). Another study (Trott et al., 1995) revealed that 35% of prescriptions for children less than a year old were for sleep disturbances and that sleep disturbances were also the most common reason for prescribing medications to preschool children (23%). Two French surveys on adolescents showed that 10–12% of the respondents reported use of prescription or over-the-counter drugs for sleep disturbances (Patois, Valatz and Alperovitch, 1993; Ledoux, Choquet and Manfredi, 1994). Recently it has been reported that of 671 community-based United States paediatricians, 75% had recommended over-the-counter and 50% prescription medicines for insomnia during the past 6 months (Owens, Rosen and Mindell, 2003). In addition, an Italian survey showed that pharmacological treatment for sleep problems was prescribed during the past 6 months by 58.54% of paediatricians and by 61.21% of child neuropsychiatrists (Bruni et al., 2004).

2.3.2 BASIC INDIVIDUAL FACTORS: GENDER AND AGE

Gender shows itself to be an important predictor of disturbed sleep in virtually all epidemiological studies (Karacan et al., 1976; Bixler, Kales and Soldatos, 1979; Ancoli-Israel and Roth, 1999; Leger et al., 2000; Sateia et al., 2000). On the other hand, there does not seem to be much of a difference in polysomnographical parameters between males and females, except for the former losing SWS with increasing age and having slightly reduced sleep efficiency also with increasing age (Williams, Karacan and Hirsch, 1974; Hume, Van and Watson, 1998). Ehlers and Kupfer (1997) timed the start of differences between genders to between 20 and 40 years. Spectral analysis also indicates slightly larger amounts of low frequency activity in females (Dijk, Beersma and Bloem, 1989; Dijk, Beersma and Van den Hofdaker, 1989). In addition, men seem to run a higher risk of morbidity and mortality related to sleep problems than women (Nilsson et al. 2001). The inconsistency between polysomnography and subjective measures has not been resolved but it may be important that most polysomnographical studies have controlled for anxiety and depression. Thus, it is conceivable that the higher level of subjective complaints in women reflects a higher prevalence of anxiety. The latter is a speculation, however. A confounding factor in gender comparisons is that phases in female biological cycles are also usually controlled for in polysomnographical studies, meaning that potential effects of, for example, menstruation, may not receive their proper weight. A recent review has gone through the literature in this area (Moline et al., 2003). It found that the luteal phase of the menstrual cycle is associated with subjective sleep problems, but polysomnographical studies have not supported this. Pregnancy affects sleep negatively as early as in the first trimester and the effects mainly involve awakenings and difficulties getting back to sleep. Napping is a frequent coping method. The post-partum period is often associated with severe sleep disruption, mainly due to feeding and comforting the infant. There seems to be some relation between sleep disruption and post-partum mood, but nothing is known about the

causal relations. Menopause seems to involve disrupted sleep in relation to hot flushes, depression/anxiety and sleep-disordered breathing. Oestrogen is associated with improved sleep quality but it is not clear whether the effects are due to a reduction of hot flushes. Oestrogen also improves sleep-disordered breathing.

With respect to background factors, age is an established predictor of disturbed sleep (Karacan et al., 1976; Bixler, Kales and Soldatos, 1979; Ancoli-Israel and Roth, 1999; Ribet and Derriennic, 1999; Leger et al., 2000; Sateia et al., 2000). Interestingly, however, older age may be related to a lower risk of impaired awakening (Åkerstedt et al., 2002c), that is, in this study it was easier to wake up and one felt better rested with increasing age, while at the same time sleep quality was lower. The increased risk of disturbed sleep is consistent with the increasingly strong interference of the circadian morning upswing of the metabolism with increasing age (Dijk and Duffy, 1999). Thus sleep maintenance is impaired and when sleep is interrupted "spontaneously", the awakening is, by definition, easily accomplished and will be lacking in inertia. This ease of awakening may be interpreted as "being well-rested", and obviously the need for sleep is not great enough to prevent an effortless transition into wakefulness.

In addition, sleep homeostasis seems to be weakened with age in the sense that sleep becomes more fragmented and SWS or power density in the delta bands decrease (Williams, Karacan and Hirsch, 1974; Bliwise, 1993; Dijk et al., 1999). As mentioned above, the effects are more pronounced in males, a fact that may be linked to reduced levels of growth hormone and testosterone.

2.3.3 PERSONS EXPOSED TO STRESSORS AS A RISK GROUP

A number of epidemiological studies point to a strong link between stress and sleep (Åkerstedt, 1987; Urponen et al., 1988; Ancoli-Israel and Roth, 1999). In fact, stress is considered the primary cause of persistent psychophysiological insomnia (Morin, Rodrigue and Ivers, 2003). That stress can affect proper sleep seems obvious, but Vgontzas et al. (2001) at Pennsylvania State University College of Medicine have found another reason why middle-aged men may be losing sleep. It is not just because of what they worry about; rather, it is due to "increased vulnerability of sleep to stress hormones".

As men age, it appears they become more sensitive to the stimulating effects of corticotropin-releasing hormones (CRH). When both young and middle-aged men were administered CRH, the older men remained awake longer and slept less deeply. (People who don't get enough of this "slow-wave" sleep may be more prone to depression.)

The increased prevalence of insomnia in middle age may, in fact, be the result of deteriorating sleep mechanisms associated with increased sensitivity to arousal-producing stress hormones, such as CRH and cortisol. In another study, the researchers compared patients with insomnia to those without sleep disturbances. They found that "insomniacs with the highest degree of sleep disturbance secreted the highest amount of cortisol, particularly in the evening and night-time hours", suggesting that chronic insomnia is a disorder of sustained hyperarousal of the body's stress response system. Also, recent epidemiological studies have shown a connection between disturbed sleep and later occurrence of stress-related disorders such as cardiovascular diseases (Parish and Shepard, 1990; Nilsson et al., 2001;

Leineweber et al., 2003) and diabetes type II (Nilsson et al., 2002). The mechanism has not been identified but both lipid and glucose metabolisms are impaired in relation to experimentally reduced sleep (Åkerstedt and Nilsson, 2003). Burnout is another result of long-term stress and a growing health problem in many industrialized countries (Weber and Jaekel-Reinhard, 2000). In Sweden, burnout is thought to account for most of the doubling of long-term sickness absence since the mid-1990s (RFV, 2003). The characteristic clinical symptoms of the condition are excessive and persistent fatigue, emotional distress and cognitive dysfunction (Kushnir and Melamed, 1992; Melamed, Kushnir and Sharom, 1992). Self-reports of disturbed sleep are pronounced in subjects scoring high on burnout (Melamed et al., 1999; Grossi et al., 2003). Since shortened and fragmented sleep is related to daytime sleepiness and impaired cognitive performance (Bonnet, 1985, 1986a, 1986b; Dinges et al., 1997; Gillberg and Åkerstedt, 1998; Åkerstedt, 1990), disturbed sleep might provide an important link between the state of chronic stress and the complaints of fatigue and cognitive dysfunction seen in burnout.

Partinen, Eskelinen and Tuomi (1984) investigated several occupational groups and found disturbed sleep to be most common among manual workers and much less so among physicians or managing directors. Geroldi et al. (1996) found in a retrospective study of older individuals (above the age of 75) that former white-collar workers reported better sleep than blue-collar workers. Kupperman et al. (1995) reported fewer sleep problems in subjects satisfied with work.

In what seems to be the most detailed study so far, Ribet and Derriennic (1999) studied more than 21 000 subjects in France, using a sleep disturbance index and logistic regression analysis. They found that shift work, a long working week, exposure to vibrations, and "having to hurry" appeared to be the main risk factors, controlling for age and gender. Disturbed sleep was more frequent in women (Karacan et al., 1976; Bixler, Kales and Soldatos, 1979; Ancoli-Israel and Roth, 1999) and in higher age groups.

The particular stressor linked to disturbed sleep may be linked to pressure of work (Urponen et al., 1988; Ancoli-Israel and Roth, 1999; Ribet and Derriennic, 1999; Åkerstedt et al., 2002b). The demands of work are a classical work stress factor and, when combined with low decision latitude, a relation has been shown to cardiovascular diseases (Theorell et al., 1998) and absenteeism (North et al., 1996). Interestingly, when "persistent thoughts about work" was added to the regression in the study by Åkerstedt et al. (2002b) this variable took over part of the role of work demands as a predictor. This suggests that it may not be work demands per se that are important, but rather their effect on unwinding after work. In two studies it has been demonstrated that even moderate worries about being woken during the night or having a negative feeling about the next day will affect sleep negatively, mainly reducing SWS (Torsvall and Åkerstedt, 1988; Kecklund and Åkerstedt, 1997). On the other hand, there is very little data to connect real life stress with polysomnographical indicators of disturbed sleep. Most studies have used rather innocuous and artificial stressors in a laboratory environment. Field studies of stress are virtually lacking, with some exceptions (Hall et al., 2000).

A lack of social support at work is a risk indicator for disturbed sleep (Åkerstedt et al., 2002b). Few previous data of this type have been found, but poor (general) social support has been associated with sleep complaints in Vietnam veterans (Fabsitz, Sholinsky and Goldberg, 1997). On the other hand, there are several studies indicating a close connection with poor social support for, for example,

cardiovascular diseases (Arnetz et al., 1986) or muscle pain (Ahlberg-Hultén, Theorell and Sigala, 1995).

Interestingly, the metabolic changes seen after sleep curtailment in normal sleepers or in insomniacs and sleep apnoeics are similar to those seen in connection with stress. That is, lipid and glucose metabolisms are increased, as are cortisol levels (Spiegel, Leproult and van Caunter, 1999; Vgontzas et al., 2000, 2001). Together with the prospective links to stress-related diseases such as diabetes type II, to cardiovascular diseases as discussed above and with mortality (Kripke et al., 1979, 2002; Åkerstedt et al., 2002a; Dew et al., 2003), the findings could suggest that disturbed sleep may be an important mediator in the development of stress-related diseases.

2.3.4 SHIFT WORK AS A RISK FACTOR FOR SLEEP DISTURBANCE AND HEALTH EFFECTS

The dominating health problem reported by shift workers is disturbed sleep and wakefulness. At least three quarters of the shift working population is affected (Åkerstedt, 1988). When comparing individuals with a very negative attitude to shift work with those with a very positive one, the strongest discriminator seems to be the ability to obtain sufficient quality of sleep during the daytime (Axelsson et al., 2004). EEG studies of rotating shift workers and similar groups have shown that day sleep is 1–4 hours shorter than night sleep (Foret and Lantin, 1972; Foret and Benoit, 1974; Matsumoto, 1978; Tilley, Wilkinson and Drud, 1981; Torsvall et al., 1989; Mitler et al., 1997). The shorter time is due to the fact that sleep is terminated after only 4–6 hours without the individual being able to return to sleep. The sleep loss is primarily taken out of stage 2 sleep and stage REM sleep (dream sleep). Stages 3 and 4 ("deep" sleep) do not seem to be affected. Furthermore, the time taken to fall asleep (sleep latency) is usually shorter. Night sleep before a morning shift is also reduced but the termination is through artificial means and the awakening usually difficult and unpleasant (Dahlgren, 1981a; Tilley et al., 1982; Åkerstedt, Kecklund and Knutsson, 1991; Kecklund, 1996).

Interestingly, day sleep does not seem to improve much across a series of night shifts (Foret and Benoit, 1978; Dahlgren, 1981b). It appears, however, that night workers sleep slightly better (longer) than rotating workers on the night shift (Kripke, Cook and Lewis, 1971; Bryden and Holdstock, 1973; Tepas et al., 1981). The long-term effects of shift work on sleep are rather poorly understood. However, Dumont, Montplaisir and Infante-Rivard (1988) found that the amount of sleep/wake and related disturbances in present day workers were positively related to their previous experience of night work. Guilleminault et al. (1982a) found an over-representation of former shift workers with different clinical sleep/wake disturbances appearing at a sleep clinic. Recently, we have shown that in pairs of twins with different night work exposure, the exposed twin reports somewhat deteriorated sleep quality and health after retirement (Ingre and Åkerstedt, 2004).

The main reason for short daytime sleep is the influence exerted by the circadian rhythm. The more sleep is postponed from the evening towards noon next day, the more truncated it becomes and when noon is reached the trend reverts (Foret and Lantin, 1972; Åkerstedt and Gillberg, 1981). Thus, sleep during the morning hours is strongly interfered with, despite the sizeable sleep loss that, logically, should enhance the ability to maintain sleep (Czeisler et al., 1980). Also, homeostatic influences control sleep. For example, the expected 4–5 hours of daytime sleep, after a

night spent awake, will be reduced to 2 hours if a normal night's sleep precedes it and to 3.5 hours if a 2-hour nap is allowed (Åkerstedt and Gillberg, 1986). Thus, the time of sleep termination depends on the balance between the circadian and homeostatic influences. The circadian homeostatic regulation of sleep has also been demonstrated in great detail in studies of forced or spontaneous desynchronization under conditions of temporal isolation and ad lib sleeping hours (Czeisler et al., 1980; Dijk and Czeisler, 1995).

2.3.4.1 Alertness, performance and safety

Night-oriented shift workers complain as much of fatigue and sleepiness as they do about disturbed sleep (Åkerstedt, 1988). The sleepiness is particularly severe on the night shift, hardly appears at all on the afternoon shift and is intermediate on the morning shift. The maximum is reached towards the early morning (05.00–07.00). Frequently, incidents of falling asleep occur during the night shift (Prokop and Prokop, 1955; Kogi and Ohta, 1975; Coleman and Dement, 1986). At least two thirds of the respondents report that they have experienced involuntary sleep during night work.

Ambulatory EEG recordings verify that incidents of actual sleep occur during night work in, for example, process operators (Torsvall et al., 1989). Other groups, such as train drivers or truck drivers show clear signs of incidents of falling asleep while driving at night (Caille and Bassano, 1977; Torsvall and Åkerstedt, 1987; Kecklund and Åkerstedt, 1993). This occurs towards the second half of the night and appears as repeated bursts of alpha and theta EEG activity, together with closed eyes and slow undulating eye movements. As a rule the bursts are short (1–15 seconds) but frequent, and seem to reflect lapses in the effort to fend off sleep. Approximately a quarter of the subjects recorded show the EEG/EOG patterns of fighting with sleep. This is clearly a larger proportion than what is found in the subjective reports of episodes of falling asleep.

As may be expected, sleepiness on the night shift is reflected in performance. One of the classics in this area is the study by Bjerner, Holm and Swensson (1955) who showed that errors in meter readings over a period of 20 years in a gas works had a pronounced peak on the night shift. There was also a secondary peak during the afternoons. Similarly, Brown (1949) demonstrated that telephone operators connected calls considerably slower at night. Hildebrandt, Rohmert and Rutenfranz (1974) found that train drivers failed to operate their alerting safety device more often at night than during the day. Most other studies of performance have used laboratory type tests and demonstrated, for example, reduced reaction time or poorer mental arithmetic on the night shift (Tepas et al., 1981; Tilley et al., 1982). Flight simulation studies have furthermore shown that the ability to "fly" a simulator (Klein, Bruner and Holtman, 1970), or to carry out a performance test (Dawson and Reid, 1997) at night may decrease to a level corresponding to that after moderate alcohol consumption ($>0.05\%$ blood alcohol). Interestingly, Wilkinson et al. (1989) demonstrated that reaction time performance on the night shift (nurses) was better in permanent than rotating shift workers.

If sleepiness is severe enough, interaction with the environment will cease and if this coincides with a critical need for action an accident may ensue. Such potential performance lapses due to night work sleepiness were seen in several of the train drivers discussed earlier (Torsvall and Åkerstedt, 1987). The transport area is where most of the available accident data on night shift sleepiness has been obtained (Lauber and Kayten, 1988). Thus, Harris (1977) and Hamelin (1987) demonstrated that single vehicle accidents have by far the greatest probability of occurring at night.

So do fatigue-related accidents (Reyner and Horne, 1995) but also most other types of accidents, for example head-on collisions and rear-end collisions (Åkerstedt, Kecklund and Horte, 2001). The National Transportation Safety Board ranks fatigue as one of the major causes of heavy vehicle accidents (NTSB, 1995).

For conventional industrial operations very little relevant data is available but fatal work accidents show a higher risk in shift workers (Åkerstedt et al., 2002a) and accidents in the automotive industry may exhibit night shift effects (Smith, Folkard and Poole, 1994). An interesting analysis has been put forward by the Association of Professional Sleep Societies' Committee on Catastrophes, Sleep and Public Policy (Mitler et al., 1988). Their consensus report notes that the nuclear plant meltdown at Chernobyl occurred at 01.35 and was due to human error (apparently related to work scheduling). Similarly, the Three Mile Island reactor accident occurred between 04.00 and 06.00 and was due not only to the stuck valve that caused a loss of coolant water but, more importantly, to the failure to recognize this event, leading to the near meltdown of the reactor. Similar incidents, although with the ultimate stage being prevented, occurred in 1985 at the Davis Besse reactor in Ohio and at the Rancho Seco reactor in California. Finally, the committee also states that the NASA Challenger space shuttle disaster stemmed from errors in judgement made in the early morning hours by people who had had insufficient sleep (through partial night work) for days prior to the launch. Still, there is very limited support for the notion that shift work outside the transport area actually carries a higher overall accident risk.

As with sleep, the two main factors behind sleepiness and performance impairment are circadian and homeostatic factors. Their effects may be difficult to separate in field studies but are clearly discernible in laboratory sleep deprivation studies (Fröberg et al., 1975) as well as in studies of forced desynchronization (Dijk, Duffy and Czeisler, 1992). Alertness falls rapidly after awakening but gradually levels out as wakefulness is extended. The circadian influence appears as a sine-shaped superimposition upon this exponential fall in alertness. Space does not permit a discussion of the derivation of these functions, but the reader is referred to Folkard and Åkerstedt (1991) in which the "three-process model of alertness regulation" is described. This model has been turned into computer software for predicting alertness and performance and to some extent accident risk.

2.3.4.2 *Health effects*

Gastrointestinal complaints are more common among night shift workers than among day workers. A review of a number of reports covering 34 047 persons with day or shift work found that ulcers occurred in 0.3–0.7% of day workers, in 5% of people with morning and afternoon shifts, in 2.515% of persons with rotating shift systems with night shifts, and in 10–30% of ex-shift workers (Angersbach et al., 1980). Several other studies have come to similar conclusions (Thiis-Evensen, 1958; Segawa et al., 1987; Harrington, 1994). Other gastrointestinal disorders, including gastritis, duodenitis and dysfunction of the digestive system are more common in shift workers than in day workers (Koller, 1983).

The pathophysiologic mechanism underlying gastrointestinal disease in shift workers is unclear, but one possible explanation is that intestinal enzymes and intestinal mobility are not synchronized with the sleep/wake pattern. Intestinal enzymes are secreted according to the circadian rhythm, and shift workers' intake of food is irregular compared with intestinal function (Suda and Saito, 1979; Smith, Colligan and Tasto, 1982). A high nightly intake of food may be related to increased lipid levels (Lennernäs, Åkerstedt and Hambræus, 1994) and eating at the circadian low point

may be associated with altered metabolic responses (Hampton et al., 1996). In addition, reduced sleep affects lipid and glucose metabolism (Spiegel, Leproult and van Cauter, 1999).

A number of studies have reported a higher incidence of cardiovascular disease, especially coronary heart disease, in male shift workers than in men who work days (for review see Kristensen, 1989; Boggild and Knutsson, 1999). A study of 504 paper mill workers followed for 15 years found a dose-response relationship between years of shift work and incidence of coronary heart disease in the exposure interval 1-20 years of shift work (Knutsson et al., 1986). A study of 79 000 female nurses in the United States gave similar results (Kawachi et al., 1995) as did a study with more than 1 million Danish men (Tüchsen, 1993) and a cohort of Finnish workers (Tenkanen et al., 1997). As with gastrointestinal disease, a high prevalence of smoking among shift workers might contribute to the increased risk of coronary heart disease, but smoking alone cannot explain the observed excess risk (Knutsson, 1989b). Another possibility is disturbances of metabolic parameters such as lipids and glucose for which there is some support as discussed above.

Only a few studies have addressed the issue of pregnancy outcome in shift workers. In one study of laboratory employees, shift work during pregnancy was related to a significantly increased risk of miscarriage (RR: 3.2) (Axelsson, Lutz and Rylander, 1984). Another study of hospital employees also demonstrated an increased risk of miscarriage (RR: 1.44, 95% CI: 0.83-2.51) (Axelsson and Rylander, 1989). Lower birth weight in infants of mothers who worked irregular hours has been reported (Axelsson and Rylander, 1989; Nurminen, 1989). No teratogenic risk associated with shift work was reported (Nurminen, 1989).

The mortality of shift and day workers was researched by Taylor and Pocock (1972), who studied 8603 male manual workers in England and Wales between 1956 and 1968. Day, shift, and ex-shift workers were compared with national figures. The Standardized Mortality Ratio (SMR) can be calculated from observed and expected deaths reported in the paper. SMRs for deaths from all causes were 97, 101 and 119 for day, shift, and ex-shift workers respectively. Although the figures might indicate an increasing trend, the differences were not statistically significant. However, the reported SMR close to 100 is remarkable because the reference population was the general male population. Most mortality studies concerned with occupational cohorts reveal SMRs lower than 100, implying a healthy workers' effect (Harrington, 1978). The same study showed a significantly increased incidence of neoplastic disease in shift workers (SMR 116). A Danish study of 6000 shift workers failed to demonstrate any excess mortality in shift workers (Boggild et al., 1999). Not much evidence exists on the connection between shift work and cancer. The mortality study by Taylor and Pocock (1972) reported an increased incidence of neoplasms in shift workers compared with the general population. A recent Danish case-control study reported an increased risk of breast cancer among 30-45-year-old women who worked mainly nights (Hansen, 2001). Among 75 000 nurses those with more than 15 years of night work showed an increased risk of colorectal cancer (Schernhammer et al., 2003). If the results are confirmed, a possible mechanism may be the low levels of the hormone melatonin, due to light exposure during the night with a subsequent suppression of melatonin.

Very few studies are available but Koller, Kundi and Cervinka (1978) found a prevalence of endocrine and metabolic disease of 3.5% in shift workers and 1.5% in day workers. Kawachi et al. (1995) found in a prospective study of shift work-

ers that the age-standardized prevalence was 5.6% at 15 years of shift work experience compared with 3.5% for no exposure. Nagaya et al. (2002) found that markers of insulin resistance were more frequent in shift workers above the age of 50 than in day workers. Other indicators, such as body mass index, glucose levels and so forth, give a rather inconclusive impression as indicated in a review by Boggild and Knutsson (1999).

Another contributing factor to gastrointestinal diseases might be the association between shift work and smoking. A number of studies have reported that smoking is more common among shift workers (Angersbach et al., 1980; Knutsson, Åkerstedt and Jonsson, 1988). Studies concerned with alcohol consumption comparing day workers and shift workers have produced conflicting results (Smith, Colligan and Tasto, 1982; Knutsson, 1989a; Romon, Nuttens and Fievet, 1992), probably due to local cultural habits. One study, which used g-glutamyltransferase as a marker of alcohol intake, did not indicate that the shift workers had a higher intake of alcohol than the day workers (Knutsson, 1989a).

Sickness absence is often used as a measure of occupational health risks. However, sickness leave is influenced by many irrelevant factors and cannot be considered as a reliable measure of true morbidity. Studies on sickness absence in day and shift workers have revealed conflicting results and there is no evidence that shift workers have more sickness absence than day workers (for review, see Harrington, 1978).

2.3.4.3 Conclusion

Shift work or similar arrangements of work hours clearly affects sleep and alertness and there is a moderate risk of cardiovascular and gastrointestinal disease. Other diseases such as cancer or diabetes may be related to shift work but the evidence is as yet rather weak.

The present review suggests that the risk of disturbed sleep increases with age but there also seems to be a recent stress-related increase in sleep disturbance in young adults. The long-term health consequences are not yet understood.

The relation between gender and disturbed sleep is confusing. Females, as a rule, complain more of sleep problems, but do not exhibit any objective indications of more disturbed sleep, at least not among otherwise healthy women. With increasing age the sleep of males deteriorates whereas that of women is relatively well upheld. Pregnancy, however, is a period of increased risk of disturbed sleep, whereas the menstrual cycle and menopause show less evidence of sleep disturbance. Clearly there is a great need for longitudinal research on gender and sleep and, in particular, on the possible health consequences connected with pregnancy.

Stress due to work or family seems to be one of the major causes of disturbed sleep. The link to the risk of insomnia is well-established, but reduced sleep in itself seems to yield the same physiological changes as stress. This suggests that several of the major civilization diseases in Europe and the United States (diabetes, cardiovascular diseases and burnout) could be mediated via disturbed sleep. This link clearly warrants longitudinal studies with interventions.

Shift workers constitute a group that suffers from disturbed sleep for most of their occupational life. The reason is the interference of work hours with the normal timing of sleep. This leads to an increased risk of accidents, directly due to excessive sleepiness, but also to cardiovascular and gastrointestinal diseases, although it is

not clear whether the latter effects are sleep related or due to circadian factors – or to a combination. Recent studies also suggest that breast cancer may result from shift work due to the effects of light on melatonin secretion. This still needs verification, however. Future research needs to identify countermeasures, the reasons for large individual differences in tolerance and the possible carcinogenic and other effects.

The conclusions above should be seen against the profound effects of reduced or fragmented sleep on the neuroendocrine (including glucose and lipid regulation) and immune systems as well as the effects on mortality, diabetes and cardiovascular disease.

2.3.5 CONCLUSION

Children, the elderly, pregnant women, people under stress and shift workers are vulnerable to (noise) disturbance of their sleep.

2.4 ACCIDENTS RELATED TO SLEEP QUALITY

As already stated in the earlier section on cardiovascular complications, children with disturbed sleep present cognitive dysfunction and behavioural disturbances, abnormal growth hormone release, increase of diastolic BP and an increased risk of accidents and use of sleeping pills.

Regarding sleep disturbance and accidents in adults, data show that 15–45% of all patients suffering from sleep apnoea, 12–30% of all patients suffering from narcolepsy and 2–8% of all patients suffering from insomnia have at least one accident (in a lifetime) related to sleepiness (statistics from the Stanford Sleep Disorders Clinic).

As already discussed in section 2.3.4, the biggest industrial catastrophes, such as the Three Mile Island, Bhopal, Chernobyl and Exxon Valdez disasters, have occurred during the night shift. The shift schedules, fatigue and sleepiness were cited as major contributing factors to each incident.

The LARES study (Large Analysis and Review of European housing and health Status) is one of the few studies analysing this issue directly. The results show that the likelihood of home accidents is significantly greater when the individual is tired all the time or most the time and there is an association between sleep disturbance and accidents, with 22% of those reporting an accident also reporting having their sleep disturbed during the previous four weeks.

The data available to document the impact of environmental noise on sleep deprivation and accidents are largely inadequate. There is no estimation of relative risk. Further research is needed in order to identify the accident-related burden of diseases attributable to noise during the night-time.

2.5 ANIMAL STUDIES

As pet owners know, cats sleep (most of the time it seems) and so do dogs. But do fish sleep? And flies? Yes, most animals sleep, and they even show the same phenomena as in humans; from deep sleep, dream sleep to sleep disorders. There are also many differences and weird behaviour, such as sleeping with only one half of the brain at a time (dolphins and ducks).

As Ising points out (Appendix 3), in animal experiments it is possible to assess the complete causal chain from noise exposure via physiological reactions and biological risk factors to morbidity or even mortality. However, a quantitative application of the results to humans is not possible. Instead, the method is useful in studying the pathomechanisms qualitatively. Rechtschaffen and Bergmann (1965) studied sleep deprivation in rats, showing that total sleep deprivation leads to mortality in 16 to 20 days. As the animals in the last stage died from microbial infection, Everson and Toth (2000) proceeded to show early infection of the lymph nodes and other tissues and hypothesized that daily sleep of some amount is necessary to maintain an intact immune system that will prevent bacterial invasion, a view that has been challenged.

Surprisingly, sleep in the common fruit fly – *Drosophila melanogaster* – has many similarities with mammalian sleep, including sleep deprivation leading to impaired performance. Genetic studies in fruit flies (Cirelli et al., 2005) led to mutant flies that can get by on 30% less sleep than their normal counterparts, thanks to a single mutation in one gene. While they sleep 30% less they show no immediate ill effects. The lifespan of the flies is, however, reduced by 30%.

These animal models certainly lead one to believe that sleep is a biological necessity, and tampering with it is dangerous for survival.

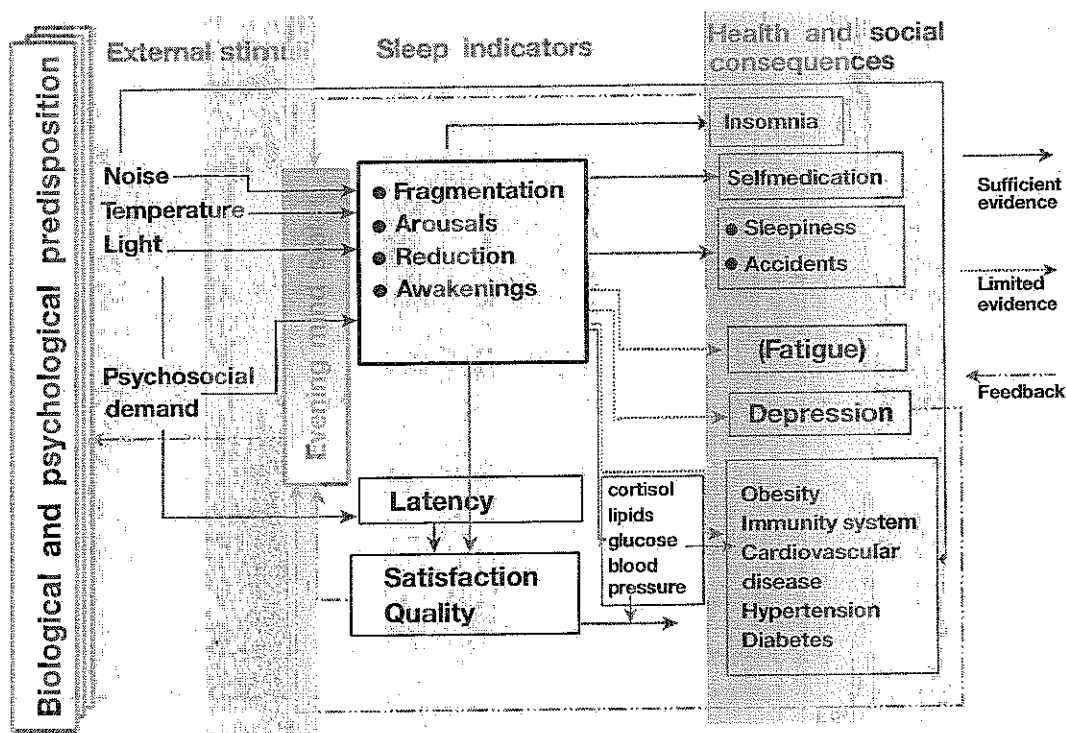
As Ising shows (Appendix 3) noise may play a role in this. Under stressful circumstances the death rate of rats is increased when noise levels are increased from “ambient” to $L_{eq}=69$ dB(A). Are noise and sleep deprivation stressors that both lead to early death? Is the noise effect due to sleep deprivation? A carefully planned study may sort this out. The question still remains, however, as to how far this is relevant to humans.

2.6 CONCLUSIONS

From the evidence presented so far it can be deduced that sleep is important for human functioning. Why exactly is less evident, but it is clear that disturbed sleep (either from internal factors or from external factors) leads to or is at least associated with fatigue, lower cognitive performance, depression, viral illness, accidents, diabetes, obesity and cardiovascular diseases. Animal experiments show that sleep deprivation shortens lifespan. The fact that – in comparison – relatively mild effects turn up in human sleep deprivation experiments could be due to the short period (about 10 days in controlled experiments) and the limitation to young and healthy adults. The central position of sleep in human functioning is summarized in Fig. 2.1. In this figure relations with sufficient evidence are indicated with solid lines, while relations for which limited evidence exists are indicated with interrupted lines. Feedback connections are in red and double-dotted.

The presence of feedback loops in the system is an indication that it may be difficult to prove direct cause-effect relations. One example is the relation between sleep quality and depression. They are strongly associated, but it is uncertain if depression causes bad sleep, or bad sleep causes depression (see also Chapter 4, section 4.8.11). This may also depend on one of the many other factors, so it could be different for different personality types.

Fig.2.1
Expert view on the relations
between sleep and health



Impaired sleep is widely considered as a health problem per se, and this chapter has shown that there are many internal and external causes. In the next chapter the relation between noise and sleep quality is further unravelled.

WindVOiCe Wind Vigilance for Ontario Communities

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

September 24, 2009

Abstract

By Lorrie Gillis
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The number of people in Ontario reporting adverse health affects due to industrial wind turbines continues to rise. The first community-based self reporting survey conducted Ontario was made public on April 22, 2009 by Dr. Robert McMurtry at the Standing Committee for the Green Energy Act. The new total is now 98 which is a disturbing 85% increase from the 53 originally reported.

Researchers and victims have reported altered living conditions and ill health. Sleep disturbance is the most common complaint. Other symptoms include inner ear problems, cardiac concerns such as arrhythmias and palpitations, headaches and cognitive and mood disturbances. Several suffered acute hypertensive episodes which are most concerning. Some have had to leave their homes in order to protect their health. These reports are consistent internationally.

Victims describe disturbed living conditions, loss of quality of life and enjoyment of their homes and property, and financial loss due to the negative impact to the health of their families.

There are unanswered questions about infants, children, and the unborn whose mothers are exposed, family members and workers such as farmers and technicians who live and work in close proximity to the wind turbines.

Modern industrial wind installations typically include large numbers of industrial scale wind turbines which stand 140m to 170m (400-500 feet) in height. Some wind turbines have been placed as close as 350m (over 1000 ft) to homes, and some homes have as many as 10 turbines within 1000m (over 3000 ft).

Each turbine requires added infrastructure such as kilometers of transmission lines, 10m (over 30 ft) wide roads for each turbine and high voltage transformer stations.

WindVOiCe fills a void due to the lack of Federal or Provincial vigilance and long term surveillance programs regarding the impact of industrial wind turbines on human health.

Comments from the victims are included in this report. They are both revealing and disturbing. No authority or compassionate member of our society can ignore the moving descriptions of the victims' experiences.

These new survey results are a startling cause for concern. Many more victims continue to come forward. More may still be sitting in silence due to non-disclosure agreements in leasing contracts with

wind developers or active law suits. Alarm now exists around the world with regard to wind energy technology, and the government of Ontario should not proceed with further wind development until authoritative guidelines based on the best available science are in place. The health and well-being of more people are potentially at risk.

Minimum requirements should include immediate implementation of:

1. Independent monitoring of
 - dBA and dBC (sound intensity or decibels)
 - hertz or frequency (high, low, infra)
 - time of exposure (cumulative effects)
2. Monitoring of wind installations at appropriate height/distance at property lines
3. Epidemiological studies of the population surrounding wind installations done annually (health surveys)
4. Clinical evaluation of victims
5. Long term surveillance for several decades
5. All information except medical records must be in the public domain.

Until these requirements are established and studies conducted, it is incumbent on the Government of Ontario to invoke the precautionary principle and declare a moratorium regarding the building of more turbines.

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WindVOiCe (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

#	Age	Gender	Occupation	Distance from turbine	Time at property	Health altered	Headaches	Palpitations	Excessive tiredness	Stress	Anxiety	Tinnitus	Hearing problems	Sleep disturbance	Migraines	Depression	Other	Approached doctor	Altered quality of life
1	54	f	farmer	800	30.5	No	No	No	No	No	No	No	No	No	No	No	n/a	Yes	
2	56		farmer	800	31	No	No	No	No	No	No	No	No	No	No	No	n/a	Yes	
3	56	m	farmer	800	35	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	
4	53	f	homemaker	800	34	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
5	45		cmi	1200	45	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	
7	50	m	self empl	800	49	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	
8	53	m	farmer	950	52	Yes	Yes					Yes				No	No	Yes	
9	n/a		farmer	1000	8	Yes	No	No				Yes	Yes			No	No	Yes	
12	63	m	retired	717	32	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	
13	60	f	retired	717	32	Yes		Yes	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes	
16	47	f	ed Asst.	1600	20			Yes									Yes	No	
17	47	m	truck driver	1600	20	unsure	Yes	Yes					Yes				Yes	No	
18	28	f	teacher	717	18	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes	No	Yes	
19	29		soc. Worker	717	vis	Yes	Yes	No	No	Yes	No	Yes	No	No	No	No	No	Yes	
21	50	f	sales	457	4	Yes	No	Yes	Yes	No	No	Yes	No	No	No	No	No	Yes	
22	52	m	seld empl	457	4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	
23	26	f	graphic	800	26	No												Yes	
24	59		retired	700	13	Yes	Yes	No	Yes	Yes			Yes	Yes	No		Yes	Yes	
27	31	m	farm	3500	2	No												Yes	
33	53	m	truck driver	1200	30		No	Yes	No	No	Yes	Yes	Yes	No	No	No	No	Yes	
34	53	f	farmer	1200	30	Yes	Yes	?	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	
38	50	m	farmer	350	10	Yes	Yes	No	No	No	Yes	No	No	No	No	No	No	Yes	
39	71	f	retired	983	3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	
40	67	m	retired	548	30	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	
41	67	f	retired	548	30	Yes	Yes	Yes	Yes	Yes			Yes					Yes	
44	65	f	retired	n/a	n/a	Yes	Yes	Yes								Yes	Yes	Yes	
45	24	m	police officer	800	11	Yes	No	No	Yes	No	No	No	No	No	No	No	No	Yes	
46	22	m	engineer	808	11	Yes	Yes	No	No	Yes	No	Yes	No	No	No	No	No	Yes	
47	19		student	808	19	Yes	No	Yes	Yes	No	Yes	No	Yes	No	No	Yes	Yes	Yes	
48	21	f	student	808	0.25	Yes	Yes	No	Yes	Yes	No	Yes	No	No	No	No	No	Yes	
49	53	f	teacher	808	11	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	
50	51	m	carpenter	808	11	Yes	Yes	No	Yes	Yes	No	n/a	Yes	No	No	Yes	No	Yes	
51	45-60	m	technician	1000	26	Yes								Yes			No	Yes	
52	45-60	f	homemaker	close	21	Yes	Yes		Yes	Yes	Yes	Yes		Yes			No	Yes	
54	53	m	ems	1000	0.67	No												Yes	
58	68	m	ret'd farmer	650	39	Yes	Yes				Yes		Yes				No	Yes	
59	42	m	bus/farmer	1000	19	Yes	No	No	Yes	Yes	Yes	Yes	No	No	No		Yes	Yes	
60	60	f	retired	750	10	No	No	No	No	No	No	No	No	No	No			Yes	
61	45-60		manager	500	20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes		Yes	Yes	
62	30-45	f	food prep	500	20	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes			No	Yes	
65	>60	m	farmer	450	45	Yes	No	No	No	Yes	Yes	No	No	No	No		Yes	Yes	
66	>60	m	farmer	650	62	No												Yes	
67	56	f	homemaker	uncle	30	Not					Yes						Yes	No	
68	45-60	f	retired	1300	32	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	No	Yes	No	Yes	
69	36	m	firefighter	550	5	Yes	No	No	Yes	Yes	Yes	No	No	Yes	No	Yes		Yes	
70	39	f	sales	550	5	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No			Yes	
71	30-45	f	access control	704	5	Yes	Yes	Yes									No	Yes	
72	30-45	m	millwright	700	2	Yes	Yes	Yes	Yes	Yes			Yes		Yes		No	Yes	
73	70	f	homemaker	800	37	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes		Yes	Yes	
74	44	f	unemployed	400	10	Maybe		Yes				Yes				Yes		Yes	
75	43	m	electrician	400	43	Maybe		Yes		Yes		Yes				Yes		Yes	
76	44	f	farmer's	n/a	n/a	Yes	Yes	Yes									No		
77	>60	m	retired	<100	30pr/12ft	Yes										Yes	No	Yes	
78	65	m	retired	800	6	Yes	Yes		Yes	Yes	Yes	Yes					Yes	Yes	
79	63	f	teacher	800	6	Yes		Yes		Yes							No	Yes	
80	79	f	retired	600	5	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	
81	58	f	farmer	1100	33	Yes	Yes		Yes	Yes	Yes	Yes				Yes	No	Yes	
82	68	m	farmer	1100	33	Yes			Yes	Yes	Yes	Yes				Yes	Yes	Yes	
83	45-60	f	healthcare	600	22	Yes	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	Yes	
84	>60	m	electrician	600	22	Yes	No	No	Yes	No	No	No	Yes	No	No	Yes	No	Yes	
85	45-60	m	retired	573	25	Yes			Yes	Yes	Yes					Yes	No	Yes	
86	59	m	farmer	800	22	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
87	46	m	mechanic	360	46	Yes	Yes	Yes		Yes		Yes					Yes	Yes	
88	45-60	f	bookkeeper	<500	23	Yes	Yes		Yes	Yes		Yes	Yes	Yes	Yes		Yes	Yes	
89	45-60	?	45-60	<500	14	Yes	Yes	No	Yes	Yes		Yes	Yes				No	Yes	

WindVOiCe (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

#	Age	Gender	Occupation	Distance from turbine	Time at property	Health altered	Headaches	Palpitations	Excessive tiredness	Stress	Anxiety	Tinnitus	Hearing problems	Sleep disturbance	Migraines	Depression	Other	Approached doctor	Altered quality of life
90	69	m	retired	450	20	Yes	No	No	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes
91	66	m	retired	1000	31				Yes	Yes							No	Yes	Yes
92	32		student	500	1	Yes	Yes	No	Yes	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes
93	46	f	homemaker	600	visitor	Yes										Yes	No	n/a	n/a
94	68		retired	500	16	Yes	No	No	Yes	No	No	Yes	No	No	No		No	Yes	Yes
95	71	m	retired	500	16	Yes		Yes				Yes						Yes	Yes
96	51	f	housewife	700	17	Yes	"	"	"	"	"	"	"	"	"		No	Yes	Yes
97	46	m	retail	700	17	Yes			Yes								No	Yes	Yes
98			retired	2000	27	No						Yes					No	Yes	Yes
99	44	m	exec director	5000	11	Yes	No	Yes	No	Yes	No	No	Yes	No	No		Yes	Yes	Yes
100	39		admin assistant	5000	11	maybe	Yes					Yes					No	maybe	maybe
101	62	m	trucker	900	10	Yes	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes
102	62	m	carpenter	500	years		Yes				Yes		Yes						
103	68	m	retired	750	11	Yes	No	No	No	No	No	No	No	No	No	Yes	No	Yes	Yes
106	45-60	f	hairstresser	400	20	Yes		Yes	Yes	Yes			Yes				No	Yes	Yes
107	52	f	Med. Secretary	600	13	Yes	Yes		Yes		Yes	Yes	Yes	Yes			No	Yes	Yes
108	44	m	Carpenter	482	5	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
109	36	f	Administration	482	1 (visitor)	Yes	Yes	No	Yes	Yes	No	Yes	No	No	No	Yes	No	Yes	Yes
110	60	f	teacher	800	1	Yes	No	No	No	Yes	No	No	Yes	No	Yes	Yes	No	Yes	Yes
111	62	m	builder	800	1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes		Yes	Yes	Yes
112	83	f	Retired	800	1	Yes									Yes	Yes	Yes	Yes	Yes
113	5	m	child	600	5	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	No		Yes	Yes	Yes
114	3	m	child	600	3	Yes	No	No	Yes	Yes	Yes	No	Yes	No	No		Yes	Yes	Yes
115	74	f	retired	700	Visitor		Yes					Yes				Yes			
116	79	f	retired	2400	48	Yes	Yes	Yes	Yes	Yes	No	No	Yes	No	Yes		Yes	Yes	Yes
117	54	f	grower horticulture	400	20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes
118	59	m	prevention services	490	22	Yes	Yes	Yes	Yes	Yes	Yes		Yes		Yes	Yes		Yes	Yes
119	57	f	farmer	490	22	Yes	Yes	Yes	Yes	Yes		Yes		Yes			No	Yes	Yes
120	59	m	farmer/	673	59	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
121	51	f	bookkeeper/	673	17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
122	29	f	Security	673	17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
123	26	f	health care/	673	17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes
124	24	f	Security	673	17	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes

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WindVOiCe (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

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Not affected: 26 respondents with no health effects

#	Age	Gender	Occupation	Distance from turbine	Time at property	Health altered	Headaches	Pallidations	Excessive tiredness	Stress	Anxiety	Tinnitus	Hearing problems	Sleep disturbance	Migraines	Depression	Other	Approached doctor	Altered quality of life
6	86	f	homemaker	800	30	No													No
10	61	f	psw	?	17	No													No
11	68	m	farmer	?	17	No													No
14	28	m	farmer	500	6	No													Yes
15	27		accountant	500	3	No													Yes
20	51		Soc. Serv.	1000	7	No													
25	57	f	retired	1000	19	No													No
26	56	m	teacher	1000	19	No													No
28	65	m	crusher op.	500	38	No													No
29	60	f	homemaker	500	38	No													No
30	28	m	farmer	1200	28	No													No
31	64	m	farmer	800	40	No													No
32	60	f	greenhouse	800	40	No													No
35	42	f	clerk	800	9.5	No	No	No	No	No	No	No	No	No	No	No	No		No
36	39	m	carpenter	800	9.5	No	No	No	No	No	No	No	No	No	No	No	No		No
37	43	f	cook	?	13	No													No
42	66	m	sales/farmer	800	26	No	No	No	No	No	No	No	No	No	No	No	No		No
43	?		retired	800	26	No													
53	n/a		trucker	900	45	No													No
55	n/a	f	homemaker	700	13	No	No	No	No	No	No	No	No	No	No	No	No		No
56	42	f	supervisor	n/a	4	No													No
57	44	m	mechanic	n/a	4	No													No
63	?		farmer	1005	34	No													No
64	?		farmer	2006	40	No													No
104	63	f	retired	close by	?	No													No
105	61	m	police officer	close	?	No													

COMMENTS

#1

8)[health affected] not sure at this time

10) [quality of life altered] The noise of the turbines is what bothers me. On a windy day, they can sound like a jet is coming right at you. They are much louder than we were led to believe they could be. In the summer when we have the windows open we have to sleep with the fans running to drown out the constant pulse of the windmills. In the winter, when it is windy, you can still hear & sometimes feel the pulsing of the windmills right through the walls.

Thankfully, the 3 closest windmills to our home are not lined up so they are not aimed at our residence at the same time.

More research into the effects of windmills should definitely be undertaken. We don't need neighbourhoods of people who have to vacate their homes b/c we have allowed turbines and their owners to take over & their effects on birds & animals. Why not people too.

11) We have not had a dog since the wind turbines were erected. We used to have barn cats, but there have been none in the barn this year.

#2

8)[health affected] No

10) [quality of life altered] On windy days we hear the turbines. Bothers me when sleeping during summers with the windows open.

#3

9)[other] High blood pressure 217/124

Had a foot that don't heal until I moved out of the house

Yes [contact doctor] Blood pressure, urine test, Doppler test, heart machine, on blood pressure pills now (Mavik 1Mg) Trandolapril [sp?]

10) [quality of life altered]

1. Had to move out of my home, just come home now to feed the cattle.
2. Our home can't be sold due to the problem per real estate agent.
3. Family events can't take place at home
4. Financial problems due to keeping two homes
5. Always sick, depressed and bad tempered when at home but when away for a short time feel much better. (Much better in the second house which I had to buy)
6. Had family problems until we moved out.
7. Feel no cares or believes us.

Bottom line:

They took life away as we knew it before the wind farm, same house value & sick all the time, financial stress now, world turned upside down.

11) 2 house dogs always sleeping, ear problems itching all the time. Moved the dogs out of house now they are fine.

#4

9)[other] Legs sore all the time

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WindVOiCe (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

Blood tests, ear testing, eye testing

10) [quality of life altered]

1. Moved out of house July 2008 until present time
2. Family problems because of family living in two places
3. Our finances are not as good because of living in two places
4. All family events including Christmas has not been in our family home
5. I always felt sick and very depressed when I was in the house and went to bed to try to get away from it.
6. The wind farm didn't seem to care.
7. No one should have this happen to them we were fine before the wind farms came

11) Yes 2 dogs always sleeping, itching, ear problems. Now they are fine when they are in different home.

#5

8)[health affected] Yes for sure!

10) [quality of life altered] I can no longer sleep at all in the summer with my window open because the noise drives me nuts. I also hear it sometimes when the windows are closed. The scenic landscape has been ruined both in the day and at night. I have had people over and we would be sitting outside at night and they tell me that those red lights would drive them crazy.

It would be hard for me to say what is worse the noise or the lights.

11) – Dog – yes now when I let him out at night He is Hyper and runs out and barks at nothing.

#7

8)[health affected] Yes, I have lost sleep, my appetite and gained headaches.

9)[other] Not yet I will contact my doctor for a check up regarding my health.

10) [quality of life altered] I have lost sleep and suffered headaches. Last year in March 2008 for one week I suffered nasty headaches, I had no appetite and could not sleep. Never before have I endured such painful headaches in my life.

#8

8)[health affected] Yes, I have performed electrical pollution testing in the homes affected and now have similar symptoms as the affected residences

9)[other] No have not consulted a doctor

10) [quality of life altered] Depending on wind direction and wind speed can hear closest turbine in our bedroom at night.

#9

10) [quality of life altered] Sleep disturbance has been the biggest thing, falling asleep for a short time and then waking up with difficulty (an hour or two) to get back or else not falling asleep at all until 2 hours after going to bed.

#12

8)[health affected] GEATLY AFFECTED.

9)[other] High Blood Pressure

Seen Doctor and have been put on Blood Pressure Medication. Chest X-ray

10) [quality of life altered]

- We have electrical pollution in our home
- Turbine noise heard in home and outside

- Causing sleepless nights, headaches, and ringing in our ears.
- It has dropped the value of our home
- Loss of enjoyment of our home
- Because of the electrical pollution our family cannot come home to visit because it is dangerous to their health.

#13

9)[other] DR. XX has given me a medical letter stating before late 2007 I had not been seen at his office for any of the symptoms listed below.

April 30/08 Dr. XX – complaint humming in ears, anxiety, stress, sleep disturbances. Removed wax from ear (rt) prescribed Rx meds for anxiety and stress. May 27/ Audiologist testing. July 15/08 Dr. XX – heart palpitations – halter monitor X 48 hrs. July 7/08 Audiologist – check tinnitus match – 3000Hz @ 15db Oct. 1/08 Dr. XX – same complaints / recommends - avoidance of home.

10) [quality of life altered] Everything in my life has changes since the town_x Wind Turbine Project company_x has been in operation. I feel my health has been compromised. I have felt generally unwell physically and mentally since March 24/08. Also Sensitivity to white noise and sounds has increased. My ears are either humming or feeling pressure on them / heart palpitations continue usually while sleeping. My anxiety and stress levels continue to be high. We have discouraged our two daughters and son-in law from visiting. They have also experienced health issues when visiting. The damage that has been done to my body – scares me what will happen in the future. At 60 – I wanted to enjoy my retirement with reasonable good health and now everything has blown up in our faces. We spent 5 weeks in Florida Jan 26 – March/09 improvement in health. Loss of enjoyment of working outside with flower beds and yard. Our property value has been greatly decreased. We are still having problems with electrical pollution. Constant reminder in every direction of our property – turbines. A very uncertain future!!

#14

10) [quality of life altered] Pays some bills with the extra income.

#15

10) [quality of life altered] A little extra income doesn't hurt!

#16

Received sleeping pills

#17

8)[health affected] Unsure if it is windmill related but I do have [...checks off symptoms]

9)[other] Doctor's appt in Jan09, only change a crestor 10mg to 5mg

#19

8)[health affected] Yes during xmas 2008 I felt pressure in my head & ringing in my ears

9)[other] [visit doctor] not at this time

10) [quality of life altered] I am unable to come home to visit my parents as often as I would like. Due to my parents ongoing adverse health effects I feel discouraged & our family dynamic has change. My childhood home no longer feels like a place to relax & where I can be in a peaceful environment. I am sick over what the turbines have done to my family & community. My quality of life has definitely been affected.

11) My dog was unable to relax in this environment.

#18

8)[health affected] Yes –whenever I am there!

9)[other] [other] Pressure in my ears or ear aches tightness feeling in my head

[doctor visit] Not at this time, these symptoms only occur around the Ripley Wind Project and not at my own residence.

10) [quality of life altered] As a teacher who spends most of my summer relaxing at home& was disrupted in July/Aug 2008 when I would leave each night with my mother to drive 10 min to a hotel in Kincardine because of the above symptoms. This is something she did for months, it was disruptive for the few weeks I did it, not a peaceful relaxing environment. In December 2008 when I arrived home to my parents on the first night for Christmas the pressure in my head and ears hurt so bad that I had difficulty sleeping and considered spending the rest of the week at a relative's home away from the wind turbines. These are regular occurrences when I visit, and now sometimes think twice before going as I don't know how bad it will be this time, which makes going home no longer relaxing and peaceful like it once was. I also worry on a daily basis for the health and well being of my parents who live through this daily and the negative health impacts and stress worries me greatly. It also causes me stress that the value of my family farm has dramatically been reduced due to these wind turbines.

11) Thank you for organizing this health survey. My family greatly appreciates it.

#20

8)[health affected] Not really

11) Haven't noticed anything

#21

[palpitations] sometimes – not often

[stress] at times frustration

[anxiety] sometimes not often

9)[other] [other] vibration/hum in house that gets into the head & body & makes sleep impossible. Torturous some nights, some not as heavy but there. Teeth seem to tingle

No treatment – waiting for closure – do not want to take any medications. Follow up visit to come after yearly physical.

10) [quality of life altered] Noise levels very high. Whooshing noise is very irritating. Cannot sleep anymore. Have horrible vibration in the house and dog very upset. Spend nights on couch with TV and try to block out humming. Extremely tired and not functioning at cognitive and physical levels that I normally would. It is very distressing and invasive. My house is worth nothing now. I could never sell it. Angry, sad, disillusioned, exhausted.

11) Dogs & cats. 1 dog extremely antsy and whining & barking when vibration/noise levels are high. 2nd dog is just starting to show symptoms similar.

#22

10) [quality of life altered] Lack of sleep – stress and home unsellable adds to stress level. Low / 60Hz Found in home keeps one up and makes left ear ring.

11) One dog barks at night for no reason – can't sleep in bedroom.

#23

6) On windy days, there is a constant pulsing noise. It is not pleasant to listen to while trying to get to sleep.

The "flicker effect". The turbines cast large shadows. In the last hours of the day, whole rooms at the west side of the house will "flicker" as the shadow of the windmill comes in and out of the room. The red blinking lights at night. Driving at night, there are 38 red blinking lights in an otherwise pitch black area. The lights are distracting, and an eye sore to the landscape.

11) We no longer have any barn cats.

#24

[comment] Because I have a conflict of interest, I am not signing my name but I do not want anyone else to suffer as we did for 8 or 9 months.

8) [health affected] Yes, from shortly after the turbines were put in operation until the transmission line was partly buried, more insulators put on, extra grounding done. Now, as far as I know, I am in good health again.

9) [other] Yes, until the problem was fixed. (fall of 08)

[excessive tiredness], because of electrical humming, could not get a good sleep.

[stress anxiety] of trying to get problem fixed.

[tinnitus hearing] I had earaches that got more and more severe. Please note: My spouse also developed earaches and headaches during this time but not as soon as me.

[migraines] I had a really bad migraine before I moved out for 3 months completely - did not return home at all except once to try it again briefly.

I did approach my doctor but he said he really wasn't knowledgeable about wind farms. A substitute doctor gave me an antibiotic to make sure there was no infection in my ears. I took the antibiotic but my ears just got worse.

10) [quality of life altered] Until the problem was fixed, I could not live at home. This was very disruptive to my life.

At first we thought the windmills themselves were the problem. However, once we had electrical testing done, we concluded the problem at our farm had more to do with harmonics and induction causing backfeed on the lines into our house. Putting our residential line on the same pole as the unfiltered or insufficiently filtered transmission lines from the wind turbines created this problem. Please note: The problem at our place has been fixed since last October since transmission lines were partially buried and extra insulators installed and extra grounding done on the dead pole south of the pole where the lines go underground. Suncor and Acciona did reimburse us for any expenses which we appreciated.

11) Once the turbines started up, our cats would not come in the house or go in the shed. Shortly after the electrical problem was fixed, the cats started going back in the shed again and in the house.

#27

10) [quality of life altered] I do not know if any changes have or can be attributed to the windmills because of the time span that I have lived at this residence. I would have to mention that through personal experience at work, which is very close to the windmills my life would be seriously altered if I lived any closer. I am quite surprised at how loud the windmills can be when surface wind speeds are low but wind at higher altitudes are swifter. I feel that this noise would very easily affect my sleeping as I'm a very light sleeper.

#28

11) 2 cats - no change.

#29

2 cats - no change.

#30

11) We have 50 dairy and young, 100 beef cows and young and so far no ill effects.

#31

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11) No changes as of yet in our animals.

#32

11) We have a dairy farm and no we haven't seen any changes.

#33

9)[other] not approached doctor

10) [quality of life altered] not sleeping.

#34

[palpitations] pressure in chest, dull and stabbing pain in chest

9)[other] joint pain, numb face, dizziness, feeling cold a lot.

Yes, doctor is aware and looking for a referral to an environmental specialist - so far no luck - not sure what next step will be.

10) [quality of life altered] Along with the above symptoms - experiencing a general lack of wellness.

#37

11) I live on a farm. My cows and dogs are fine.

#38

8)[health affected] Morning headaches and some ringing in the ears.

9)[other] No, I've not approached my doctor. I just returned from Manitoba at Xmas.

10) [quality of life altered] I farm in Manitoba (8 months/year) and Ontario (4 months/year) and when I'm here in Ontario I develop headaches. I take 3 tylenol (500mg) every morning and then I'm good to go.

#39

9)[other] severe headaches, but migraines?

[doctor] No doctor

10) [quality of life altered] Headaches etc. prevent me from living my life the way I would like too. Also my home seems to be unstable the way it is, ie turbines in the vicinity.

11) Don't know

#40

Struck/hart palpitations

9)[other] Stress tests/ blood tests to numerous to count.

10) [quality of life altered] I now live on drugs that don't seem to help.

11) Livestock were all sold of due to problems that could not be explained. (Nervousness)

#41

10) [quality of life altered] Forced to sell our property, take less then what it was really worth!! This was due to health problems caused by the wind turbines.

11) Our dogs were nervous, as well as our four(4) ponies. We ended up taking our ponies too the auction barns and had them sold. Two of our dogs had to be put down!!

#44

9)[other] 1.vibration in body 2. chest and head pressure 3. heart rhythm sensations 4.nausea,queasy 5. dizziness

9)[other] queasiness, mild vibration in head and chest, heart sensations – felt like the beat of my heart changed by turbine.

[doctor] Yes, checkup.

10) I experienced severe health effects from exposure to a single wind turbine while on vacation and never, ever want to experience these health effects ever again. The vibration and breast sensations were very frightening and debilitating.

11) [quality of life altered] I experienced this attack when exposed to a small wind turbine group of 2 turbines. The wind was moderate and my symptoms were very uncomfortable. I left the area very quickly and felt better within an hour or two. I will avoid these turbines when ever possible because the health effects are very uncomfortable and distressing. Turbines make me feel very sick when I get near them. I am OK when I leave the area where they are installed.

11)n/a

#45

10) [quality of life altered] My stress level increased while at home for the 4 months. Now within my life I am stressed and I worry about the physical health of Mom, Dad and Erin as well as friends and neighbours in the wind project. I worry about my families financial health too, whether the property has any value. At the worst i was worried about Mom and Dad marriage because of disagreement which flared up more than ever before. I did not think about the above prior to the wind complex starting.

11) No.

#46

9)[other] No. Problems with the above go away when I leave the (wind project) home.

10) [quality of life altered]I feel wound up when at home. I just cannot settle. Because of this I do not want to stay in our home or for that matter come home. the biggest change has been the effect on my Mom, sister and Dad's health, especially Mom. To see her suffering from health problems, getting sicker and sicker just pisses me off. It really bothers me a lot.

11) No.

#47

[palpitations] a lot

[tinnitus] all the time

9)[other] stomach felt full, air hurt, rapid weight loss 170 to 125lb over 3 months and loose stools, more extremely exhausted, not as patient, get angry fast.

/For weight, (Dr. at school) get weigh up since it was in the danger zone for my height.

10) [quality of life altered] For myself I was more angry. Mom and I have always been able to talk. Last winter we argued about the stupidest things. I have very, very, very low energy and just want to sleep. My family has been ripped apart with Mom not able to live at home. Not having Mom around to talk to about school or friend and personal stuff has been and is hard. Very hard.

Mom use to talk about other things, fun stuff, but windmills have become the main topic. I hate that.

11) No.

#48

[sleep disturbance] had to get to sleep upstairs.

10) [quality of life altered] The sleep disturbance - over all feeling of wellness was very poor.

11) No.

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#49

[headaches] at the back of the head/neck

9)[other] A jumpy feeling as if you have had 5 cups of coffee, humming in the head behind the ears, very painful left hip, spiking pain, loose stools, cold body temp, blurred vision when winds are high, some dizziness, increasing blood pressure, nerve pain from the left ear to jaw, 2 large coldsore masses one time, shortness of breath, tight chest and knot in left chest.

[approached doctor for] ear, heart and chest.

Yes, Family Physician, May, 2008, blood tests, orders 12.5mg fluid pills, auditory assessment by ear, nose and throat specialist (order a CT scan to eliminate tumor or abnormality and hearing assessment June to August, 2008) Feb. 18/2009 Family physician Bp and cold sores - ordered double Bp meds, sleeping pills, antiviral and antibiotics, purchase Bp cuff and blood work. Feb. 22/09 Bp, heart, chest, heart monitor, emerg bed. O2 monitor, Bp, "pink lady", Nitro spray under tongue, order - change living place, 4 days off work, rest, stress reflex test. Specialist consult. Stress test (order - Bp med, change of living place or modification; reevaluate in one month.

10) [quality of life altered] I used to be able to get a solid 6-8 hours, full of dreams and nap or snooze without any effort. I have been severely sleep deprived from Nov. 2007 to May 2008, attempted rest at billets in town paid for by wind_co_x. When [W.C.] turned off the field your whole body felt calm and like you have had a massage, humming or ringing subsided and could deep sleep. Again in the last week of Aug. 2008 to Feb. 2009 sleep deprived, waking up to 3 times or if the winds are high it seems like every hour and hard to drop off to sleep. Humming in the head occurring behind the ear and started wearing cotton batton, then over time orange ear plugs and head phones. (This did not stop the humming then latter ringing then buzzing and ringing*. The ability to hear my students even while working at the board has changed to walking across the room or asking for them to repeat louder the answers or questions. I can not listen to loud T.V. or music or sounds. At the worst I struggled to go into the Sobeys Store, the lights made ears ring and similar environments (i.e. C.T. store). Now I am more sensitive to vibrations and high frequency electrical pollution which means some high tech equipment is more annoying than prior to Nov. 2007. All symptoms subside with less exposure and sleep**. *Change - I would attempt sleep in the spare room or in the basement. **As a family we shut off and unplugged as many appliances as possible prior to trying to sleep and when home. Difficult to form thoughts to come out of my mouth. I stuttered on my words. When tired, I would wear a lot of extra clothes to try and warm up, too.

Family - oh, our normal problem-solving skills between family members were not attempted. We were very irritable. We had loud angry arguments. I was constantly worried and concerned about the health changes in my family. That there was no way to change. We did not invite the Grand mothers over to visit much or stay over due to the concern for their health. The same can be said for inviting family or kid's friends over.

Changes - for the second time I am not home and have to help co-ordinate food, cars, laundry, mail and financial from a distance. May - June 2008 - up [at] 6:00 home to pick up [daughter] 2-3 times/week, 8:00a.m. on other days for Rugby, teach, home for setting up meals and lunches (with ears plugged and sometimes head phones), back to town_z with clothes, homework and bed. Now I am in town_y and going home every 2/day and into school(maybe). We send love over the phone or on message sheets on the counter. Have spent a massive number of hours, totally days of family time, working to get the problems resolved.

Personal Change - My love, [husband] ie worries and I worry about him and [daughter]. I truly miss being happy in my home. My home was my calm space where I could unwind after a day at highschool. No other space can replace the home where you have helped raise your family and had so many positive plans for the future. I miss [husband]. I miss [daughter]. Lost total faith in government to safeguard myself, my family and other Ontario families. I do not trust the word or intentions of experts compared to before Nov. 2007.

Job Change - I love to organize, plan and teach a lesson. I have taken pride over 27 years to be able to

call students by name at any point in the lesson. Change, I took 1 1/2 hours to get a lesson organized. I had trouble remembering the lesson or where I was in a lesson. I had to work so hard to remember facts which should be 2nd nature. It was hard for me to get the first word or name out of my mouth and the right students name. My co workers were extremely worried about my deteriorating health and the lack of progress with governments and companies to fix the problem. Change in 27 years I have rarely been absent for illness. Feb.22/09 I had Dr. orders to not work and I requested one week, but, my principal recommended another week to rest away from home as ordered by 2 physicians.

Financial. did not have to worry about property value. Now our home is worthless unless someone can fix this mess. I could not in any moral consciousness sell knowing how we are affected.

Outside change. I do not and have not felt like going out into the gardens which has been a calming passion my entire life since I was a child. We as a family do not sit on the deck as much due to jet sound or roaring. We close our window in the summer due to roaring jets or rattling sheet metal sound. We could not cool the house and ourselves as well, too. I will say there are probably other alterations like not being there for [daughter] as a young person needing advice and her Mom, but I am going to stop!

11) Moved Horses prior to start up of turbines.

#50

9)[other] [tinnitus] pop when turbines come on and off.

[sleep disturbance] Do not sleep a full night. Wake up quite often.

[other] nasal cavity felt like I had allergies, but no mucus, Irritable.

10) [quality of life altered] Personal -- have found the changes in sleep patterns reduced energy levels, levels of patience and very frustrating and draining. Dec. on there were serious, angry arguments we normally do not have. I am very worried about my partner's, [wife], reduced sleep/rest, humming/ringing in her ears and continued deterioration of health. When [wife] had to live away from home it was hard. She is my partner and my love. We would always chat on family plans from food to finances. Our lives were upside down at all family levels when she was billeted by the windmill company wind_co_x from May 2008 to July 17th and AGAIN now. She is living at her Mom's in town_y a 30 minute drive away (on Dr. orders). On a very personal level I am like a widower and sad and lonely.

Generally - Our financial outlook for our property has changed. At present we can not sell knowing the possible harm that someone may experience. This is a stressor we did not have prior to the turbines. I can't sleep with the bedroom window open in the summer for a cool breeze due to the roaring jet sound. (This was pleasant and cooling too.) I can't have a quiet sit on the deck without the jet or swoosh sound. And our phone has static on it which is not there when turbine were not here. CKNX am channel is static or weaker in the project area

#51

10) [quality of life altered] The visual impact of the navigation lights has had a profoundly negative effect on our night sky. In the day-time the obvious industrialization of our landscape adds to this demoralization. When weather conditions are right the turbines can be heard from outside our house again having a negative effect on the quality of our life in the country.

11) No.

#52

6) Too close - I'm sure the bare minimum.

10) [quality of life altered] The constant changing sound changing to a horrible noise startles me, my dog and sometimes even the birds. The constant distant buzz in my head because of the substation - it's always there. The blinking red lights at night just depresses me and ticks me off. I might as well be at an airport landing strip. The same goes when I just look around. There aren't the same birds or their numbers anymore. I never see the deer anymore and to see the skyline no matter which way I turn ruined by the number of these things does give me a headache. I can count over 70 windmills from my

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property.

11) The cats don't go as far out back as they used to. When they're really noisy especially right before they shut down startles the dog. If it's at night, he's reluctant to go towards the noise and wants to come back in. The flyway for the swans is all windmills now so I'll see if they come again this spring as they've done for years. The owls aren't around in the numbers they were.

#53

8)[health affected] None what so ever.

10) [quality of life altered] No not at all

11) I have pets no change same as they have always been.

#54

8)[health affected] Not that I'm aware of

10) [quality of life altered] I have 2 reasons;

1. I don't particularly like looking at them.

2. If the wind is a certain way I can hear them even though the closest is 1 km. away. Some days it sounds like a jet aircraft in the distance, and some days its more of a swishing sound. It seems to vary depending on wind speed and direction. I am definately opposed to any more going up in our neighbourhood.

#55

8)[health affected] Not at all there has been no change.

9)[other] There have been no problems at all.

11) None whatsoever.

#56

11) no

#57

11) no

#58

10) The flicker from the turbines can be very annoying in the mornings. When I'm training horses for 3 to 4 hours the noise gets to you and you have to stop for awhile and go to the house. In the summer when windows are open you can hear them in the house. There is also some problems with some of the neighbours around me because of stray electricity. I have not had mine checked.

11) When the turbines are noisy, the horses always go to the far side of the barn.

#59

9)[other] Yes, I went to doctor for stomach scope/colonoscopy because I was afraid I had stomach ulcer.

10) [quality of life altered] *I don't like the looks of them.

*I don't like the noise they make, I can hear them all the time.

*Shadow flickering is a problem.

*It used to be "nature" only, fields, trees peaceful but now you can only see these ugly looking windmills

*At night I hate the "red" lights on top of the wind mills blinking.

*When I go for a walk with our dog, the closer I get to windmill, the more my ears ring.

*Since they erected the windmills I felt stomach pains(still today) and went to the doctor for stomach scope and colonoscopy, all was fine but I still have stomach pains. I don't know if it has anything to do with the windmills.

*At the beginning when they put up the windmills I had anxiety problems, I hated the windmills.

*At night my wife and me wake up to some weird ringing in our ears/it comes and goes.

11) No livestock, but I know since they put up the windmills, we have not heard any coyotes or wolves howling at night, strange.

#60

10) [quality of life altered] The only way I feel that the turbines have impacted my life is the noise when the wind is strong. Even at night it is difficult to block out the sound of the blades. I do feel badly for those neighbours who are experiencing serious health and sleep problems. It is the responsibility of the wind turbine company and/or Hydro One to ensure that their life and health returns to pre wind turbine quality.

#61

9) [other] Yes, doctor did blood tests, oral scope, prescribed sleeping pills, referred me to therapist and a nutritionist, sent me to a sleep clinic, I was vomiting blood.

10) [quality of life altered] We lived in this house for twenty years with the plan that we would pay it off, borrow money to purchase our retirement home and then sell the house to pay for the retirement home. We put the house up for sale the year before the turbines were built and real estate agents told us, people were worried about where the turbines would be placed and the house did not sell. Now the turbines are up and I can count 30 of them from my property. My wife and I can hear them when we are outside and we experience flicker when we are inside. We can see them through every window in the house in the daytime and we see the sea of red flashing lights every night. We live in a school house we took from being vacant for twenty years to a beautiful open concept home in a quiet country setting. Our friends and family have loved our home for years but now just shake their heads when they [see] what has happened here. Don't know what's going to happen to me in five years when I'm ready to retire if I can't sell my house.

11) n/a

#62

9)[other] Not as of yet.

10) [quality of life altered] I feel like I don't wish to live here since the day the turbines have been erected in our area.....

Their distracting (flicker, etc)

Their ugly(including the switchyard out back of property)

Their noisy

They look dangerous to be around them.

I here a low humming noise while trying to sleep and I can't function as I normally could before during the day.

11)n/a

#63

12) no changes

#64

13) no change.

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#65

09)[other] Increased blood pressure medication.

10) [quality of life altered] To bring you up to speed, I own 200 acres of prime farmland which is completely surrounded by turbines. At last count we had 37 red flashing lights, disturbing noise. AM/FM interference and shadow flicker on sunny days.

My anxiety and stress is mainly caused by the fact that we don't know what the long-term health effects will be, if any. When I read about the health problems I worry about the value of my farm which is my retirement fund.

It's interesting to note that the lawyer for Enbridge at the OMB hearing with our WAG group, is now fighting to keep windmills away from her home at Honeywood.

I've read and kept all your letters and presentations on the subject. Keep up the good work!

11) None at the present time.

#66

08) not so far, the windmills just started up.

09) noise issue

night sky is full of flashing red lights

visibility of area with the density of windmills

#67

08) [health affected] not sure

09)[other] Been twice to the Dr. with ear problems – June and Oct, 2008, no results. Dr. couldn't find anything wrong.

11)n/a

#68

10) It causes me ill feelings to continually have to look out each window of my home to see spinning towers. At night the continued flashing lights invade a once Peaceful Sky.

Industrial Energy Projects belong on industrial zoned land.

#69

10) [quality of life altered] We bought this property to be away from the noise of the city and road traffic now all I hear is the windmills. I love to be outside, walking, hunting in our bush. Now all I hear is the windmills. Peace and quite no longer exists. The rear of our house is all windows, at night all you see is the warning lights. It is driving me crazy. We had no say in the mills because we weren't getting one. The persons that got them get paid and don't live near them. I'm sure our property value has went down because of them. This summer will be the first time we can lay by our pool and I'm sure they will drive me.

#70

09)[other] [hearing problems] not sure

[migraines] not sure – bad headache

11) n/a, No Pets.

#71

10) [quality of life altered] If these symptoms are caused by the turbines, my quality of life is effected.

The windmills are a distraction when your trying to keep your eyes on the road. Also the red lights on every other one flashing at night are a sure spoiler in the nice countryside.

#72

10) [quality of life altered] The constant noise is like an alarm clock going off all the time and at sunset the flicker can make me dizzy.

11) N/A

#73

9) [other] I talked to a Clinic Dr., but he wasn't concerned.

The windmills are very noisy when we have a strong wind. When the sun comes up we have a shadow that makes like the lights are going off and on in the house.

10) [quality of life altered] No.

#74

8) [health affected] maybe, but how can you pinpoint it at the windmills.

9) [Other] joints + muscle soreness.

[Doctor] Yes, but I never asked if it would have anything to do with the windmills. I have had no tests done.

8) [health affected] I'am a nature person, and I find since the windtowers have come here, there is hardly any wildlife, my bird population has pretty much deminished. I also like peace and quite which has been lost, because of the noise of the turbines. I feel tired all the time and my muscles and joints are sore and I feel achy all the time.

9) [Other] dog-having problems with his ears, vet calls it swimmers ear, but we don't take him swimming, or bath him especially in the winter.

#75

8) [health affected] Maybe – do not know how you can say for sure.

9)[other] [other] itchy EARS

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10) [quality of life altered] I always feel tired. I do not like to hear the turbines. Peace and quiet has been lost. I do not know what makes my ear itch by it is very irritating.

11) Do[g] has problems with ears, Vet says it is swimmers EAR but we do not take him swimming.

#76

05) [wind farm near property?] None – we spend time near 'town x'.

8) [health altered] When we are in the area yes. No, as we leave the area the symptoms vanish.

#77

9)[other] [other] spatial infringement.

10) [quality of life altered] The wind turbines are across the road from the property and one is in direct line with my driveway. Every time I go out the lane I look right at the turbine.

My home has large front windows with a pastoral view. Now it is full of wind turbines. I now have to keep the curtains pulled to avoid looking at them. I find the continuous turning of the blades quite disconcerting. At night the once dark sky is now filled with blinking red lights so again requiring the blind to be closed, definitely affecting my life. I am away for 5 months in the winter coming back in early April so have not had the full exposure to the turbines. These wind turbines are the only ones I have seen that are built in such close proximity to homes.

It is equally disturbing to know that our politicians and so called "leaders" have such blatant disregard for individual lives. This is also applicable to so called neighbours.

Thankyou for all the work that is being done to ensure a more regulated and humane system.

#78

9)[other] [Doctor] Discussed symptoms with doctor twice. At this point we will further monitor my symptoms and discuss possible actions (tests, etc.)

10) [quality of life altered] This previously peaceful/quiet area was to be our retirement home. We are now considering changing our plans. Any further improvement to this property is on hold.

Depending on wind direction there is a loud pulsating, intrusive swooshing noise. I seem to sense a vibration in the air and at times I seem to sense the changing air pressure (like descending in an airplane.)

I spend 80% of my time in [turbine town x] and 20% in [town y]. When in [town y] I sleep better, less headaches and more relaxed.

11) N/A

#79

9)[other] [doctor] No – I do not yet live full time at this address. If I were permanently here, I might find the symptoms severe enough to seek medical help.

10) [quality of life altered] The peace and quiet of this potential retirement home has been compromised. The noise at times is intrusive and impossible to ignore. I am also concerned about long term exposure to low frequency vibrations; as a result, our plans to retire here are on hold and may need to change.

#80

9)[other] [other] Nausea, sound like tomtom, sharp knife-like pain in muscles, twitching in skeletal muscles and around eyes, hypertension (168/80)

[doctor] Yes. I will be following up with hearing tests at UWO which will be compared with such tests done at the Toronto Hearing Society facility. MRI test is scheduled for May.

10) [quality of life altered] In order to accommodate a condition diagnosed as fibromyalgia, I sold a four level house in Toronto and put all the proceeds into building a one level house which would handle wheel chair living. My new house just west of [town x] made my daily activities doable and my health started to improve.

When AIM Power gen started building industrial wind turbines I was perturbed and stressed by the presence of these behemoths and the effect they would have in this major migratory bird corridor, not thinking they would affect my life.

While I was distressed by the sight of the first phase of turbines which were more than three km from my house, it was the connection of the last six turbines erected in a semi circle around my house that brought on symptoms which I had never had before and which exacerbated the hypertension.

So now I am researching ways of regaining some of my health again although the hyperthyroid, diabetes, scleroderma, fibromyalgia conditions continue.

11) No pets or livestock but anecdotally have seen that tundra swans no longer feed in fields which have industrial wind turbines on their migration north in the spring.

[additional comment] These are the industrial wind turbines around my house. A & C are about 600m away, B is 700 m and D is 800m.[away] E is 1.9km.[away] G is 2.2km.[away] F is 1.9km. [away]

#81

8) [health affected] Yes – but we can't prove it.

9)[other] [other] sore joints & sore back of hands, memory loss.

10) [quality of life altered] – due to health problems.

#82

8)[health affected] Yes – but we can't prove it.

9)[other] Joints-painful, sores on head.

[doctor] Yes regarding sores on head – all they gave was medicated salve.

10)[quality of life altered] Yes, the above health problems.

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11) [pets/livestock] We are cow/calf producers. We feel our cattle are more high strung. Our calving pattern is effected – we get calves then no calves for a couple of weeks usually when we are calving, once we start we get a calf/day.

Last fall the earth worms-hundreds of them-were on top of the gravel and on top of the cement – in the morning when we saw them they were dead.

#83

9)[other] nausea, muscle pain, irritability

10) [quality of life altered] To avoid morning flicker must have blinds or avoid rooms until it passes. When warm weather arrives noise from turbines will limit opening of windows especially at night for sleeping.

Will not enjoy evenings out of doors on decks due to all the Red Flashing lights and noise.

11)N/A

#84

9)[other] [other] irritability

10) [quality of life altered] can't be outside any length of time due to noise and in am the Flicker. Red flashing lights at night make it impossible to sit outside for long at night. Won't be able to open windows at night when warm weather comes due to noise.

11) N/A

#85

9)[other] enjoyment of my property

10) [quality of life altered] -> worry about house value

-> can't go outside – noise

-> every window I look out I see wind turbines

-> flicker issues at certain times of day on house walls inside & reflections on windows.

-> those things have greatly disturbed my setting and how I was use to functioning for the last 25 years at my home.

11) -> no longer see wild geese or wild turkey in the field?

#86

8) [health affected] I am severely limited in any physical work managing biosolids application company, but suffer constantly from muscle cramp pain.

9)[other] developed Parkinson's disease 2 years ago

[doctor] drugs for migraines, 12 Sinnamet capsules for Parkinson's, 4 tabs Comtan, cost \$4000 year, no drug plan, poor writing due to loss of fine motor skills.

10) [quality of life altered] We hear wind noise from turbines every evening while sitting on our deck. The setbacks are 800m, 1100m, 2000m, 1000m, 1500m, 2000m.

At nights we hear them in our bedroom a 17 year old home with R2000 standards.

Severe trembling with Right hand and foot, people think I am drunk when in town, due to some paralysis on right side. Even harassed by OPP.....[illegible]... "drunk".

11)) [pets/livestock] We keep about 20 nanny goats, for the past 20 months they have had abortions, not a single kid was born alive, all aborted before term, others died within 3 hours of birth.

#87

[disturbed by wind turbine transformer]

9)[other] [headaches] moderate to severe, daily occurrence

[tinnitus] occasionally 3 or 4 times per month

[sleep disturbance] almost nightly

[doctor] CT scan, MRI, visit to neurologist, pain management clinic, echocardiogram. All tests negative, its not me, is doctors conclusion. Pain management clinic doctor agreed that based on my chart the transformer is probably the problem since when I leave home symptoms disapate.

10) [life affected] It is very hard to work when you have a daily headache which varies from moderate to severe. It hasn't been less than slight headache in approximately 18 months. Always tired. Ringing in ears sometimes a high pitched squeal lasting for up to 10 minutes at a time. Body aches on awakening for last couple of months

Severe Headache, Pain to the point that a single shake of my head will result in vomiting. I take no medication since my doctor tries many different ones and all they would do is make me sick, did not help the headache.

List of drugs for headache that didn't work, Tramacet, Tylenol3 w. codeine, Apo Nortriptylene, Apo Propanolol, Dilavdil, Apo Hydroxyzine, Apo Naproxen, Endocet

Compared to this issue having my leg broken in two places was a picnic!

11) None.

#88

9)[other] Have no family doctor. Went to emerg currently awaiting a CT scan.

10) [quality of life altered] Constant noise, constant headaches. Sleep disturbance since the windtowers have started.

We have recently put a 500' addition on our home with large windows all around. Not only we get flickering from the towers we cannot open any windows due to the constant noise of the blades.

My occupation is a bookkeeper. These constant headaches are affecting my concentration, especially working with numbers. I work from my home. I simply cannot afford to be in ill health.

I can no longer sit on my back porch enjoying the beautiful sunsets. This was so relaxing to me. Now all I see is flickering blades and blinding red lights. The sunsets have disappeared into money hungry pockets of our government.

This area was once known as having the most beautiful sunsets in the world, now gone!

I now am a prisoner in my own home of 23 years.

This is not the future I wanted! That is why I bought this property 23 years ago. Now I am going to sell and start all over again. Extremely depressing!

11) My horses are nervous of the noise and do not focus on what they are doing. Instead they watch the windmills making this a danger when riding or training them. My dogs and cats want to stay in the house more now. This is very unusual for them.

#89

9)[other] I currently have no family doctor.

10) [quality of life altered] The measurement of one's quality of life is something difficult to qualify. That being said, I know what my life was like before the towers went up and I know what it is like now. Aside from the aforementioned health concerns there are many other factors that are of concern for myself. I have spent many years living on this property and making improvement to it. These improvements were compatible with the rural area in which I am located. Now I cannot enjoy quiet evenings (turbine noise), beautiful sunsets (turbines flashing on horizons – 67 can be viewed from my place) and star filled nights (bright and flashing lights in every direction).

These things may not seem important to those who don't live here, but they are important to me and you just can't put prices on that. My various levels of gov't has deserted me and ignore my concerns.

This is not the future I had planned when I invested my energy, time and money in this place. I choose to live here for what it was, not what it has become. The addition of this wind project has upset the balance of this area and will, without a doubt, drive me from this area. This will happen with great financial loss to my family and the thought of starting over else where is almost intolerable, too much of me has gone into this – my home. Add this to the health concerns and we are looking at a disaster in the waiting.

11) I have noticed that the horses are far more nervous and more easily spooked. My dogs at times will not leave the house and are acting very out of character at times.

#90

8)[health affected] Yes, I find myself very easily irritated. Every window in our home has at least 10 or more windmills.

9) [hearing problems] Good thing I am ½ deaf.

10) [quality of life altered] People who were good neighbours are now looking away and don't want to talk any more if they have windmills or are in favor. Our beautiful view is now gone as from my back deck I can count 72 wind mills. My property values have gone down the drain by around \$100,000. Most of the owners of the landowners with turbines on the farm do not live around here. They live many miles away.

11) My dog gets very upset when anyone comes to the door.

#91

9) [doctor] As of this time I do not have any physical symptoms

10) [quality of life altered] The present govt. has an agenda to promote these mills even though they are unreliable as a steady source of power & will only ever amount to a very small percentage of the power req'd on the grid. I live on the north limit of the [X wind farm] and so far I am fortunate to be as far away from the turbines as I am. However, land options have been acquired in [S. township] and I will not fair as well should they go ahead there.

I know my property value has been reduced to some degree and it is a constant worry where they will relocate to next.

With regards to noise, if the wind is blowing towards our residence they can be heard even at a km (3300') away. (Not inside the house) At night the sky is filled with blinking red lights which is something else to contend with. The above are some of my concerns which I believe contribute to increased stress & anxiety.

11) No pets or livestock

#92

9) [hearing problems] right ear only

[other symptoms] tones change in hearing, popping excessively

[doctor] Yes, My migraines and popping of ears and fatigue. Hearing tests. My tx-treatment higher enriched diet for ears, migraines. Migraine relieve advil.

10) 10) [quality of life altered] People who were good neighbours are now looking away and don't want to talk any more if they have windmills or are in favor. Our beautiful view is now gone as from my back deck I can count 72 wind mills. My property values have gone down the drain by around \$100,000. Most of the owners of the landowners with turbines on the farm do not live around here. They live many miles away.

My life has been altered slightly. When I go outside there ugly to look at, when wind is strong my symptoms are strong as well but in the long run, the windmills haven't altered my life significantly. Windmills are the future, whether I like them or not, I am one person I live for change! Do I want more

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around where I choose to live, the answer will be no. Do I plan to live here long? NO I noticed behaviour changes in my animals, yes, my dogs and horses shake their ears a lot but do I have testing and evidence to back up my theory? NO!

#93

5) [wind farm near property] This occurred when I visited a home in the [windfarm] project

7) [how long living at property] N/A – was a visit only.

9)[other] pain below my right ear, where my jaw bone ends after visiting in this home for 4 hours. The pain disappeared after I left this home and returned to my own residence.

#94

9)[doctor] not yet.

10)[quality of life altered] Cannot sit outside anymore because the noise. Have to sleep in summer with the windows closed.

11) We have a cat who no longer wants to go outside since we have the turbines.

#95

10)[quality of life altered] The prevailing wind is from the West and we are downwind of a cluster of wind turbines which generate a lot of noise, when sleeping with the windows open. It is being heard in the bedroom.

11) Our cat stays now more inside.

#96

8)[health affected] Stress.

9)[symptoms] I have a pre-existing medical condition. Therefore this question cannot be answered accurately.

10) Noise & radio interference devalued our property

At times: "Noise" from the turbines is very annoying. At times sounds like we are living right next to an airport. Can even hear them "at times" when all our windows are closed

"Radio interference is an issue as well. Can hear the blades turning (static) through our radio

Also, they are unsightly. May have affected our property value.

11) Yes, my "therapy dog" is really apprehensive to go outside at night (to do her business) when the turbines are so noisy.

#97

8) [health affected] A little stressed

10) [quality of life altered] Somewhat. Noise from the blades turning. Radio interference. Also, may affect our property value.

11) At times: Noise from the blades stresses our dog.

#98

10) [quality of life altered] The flickering bothers us when we sit in our sunroom or deck in the afternoon. The noise is equally disturbing – especially at night sometimes we have to close our windows.

#99

8) [health altered] Yes, there may be a connection

9) [doctor] Mentioned to my Doctor outside of office, have not made an appointment. I am very healthy, thin, athletic and exercise often.

10) [quality of life altered] Prior to the installation I was always a high energy, upbeat person who slept well. Late in the fall of 2008, my wife and I started experiencing heart palpitations when trying to sleep. We can both hear our pulse in our ears. We never connected this to turbines until now. I am less energetic, lacking in ambition, more moody and less optimistic. My whole state of mind has changed. It has impacted my work & home life. I cannot see or hear the turbines from my home. The symptoms were worse in the fall and winter and better in the spring. If our symptoms increase next fall and winter we will know it is linked to the turbines and wind speed/direction.

11) No pets or livestock.

#100

8) [health altered] possibly, but uncertain

9) [doctor] No. I have noticed that I have experienced heart palpitations or increased pulse, sometimes during the day and sometimes while resting through the night, which has caused some disturbance to my sleep. I am not sure if these are linked to the recent start-up of the nearby wind turbines, but I believe I have been experiencing these symptoms over the past 6 – 8 months.

10) [quality of quality of life altered] possibly, if what I have experienced is in fact linked to the operation of the turbines

#101

9) My doctor does not understand the situation.

10) [approached doctor] My doctor does not have any information on the symptoms. I believe my quality of life has deteriorated as have my property values.

11) My dogs seem to be more clingy towards me and seem to overreact when I return after being away for several hours.

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Wind VOiCe (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

#102

10)[quality of life altered] Some days its like camping at the end of an airport.

11)Deer and turkeys moved out of area.

#103

9)[other] annoyed at visual sight as well as hearing the noise generated.

10)[life altered] Was expecting to enjoy peace and tranquility, not being intruded upon by the multitude of turbines.

#104

10)[quality of life altered] I resent the fact that WAG[wind action group] has interfered with my privacy by submitting this in my mailbox. I refuse to listen or acknowledge WAG;s underhanded methods.

#105

10)[quality of life altered] I am disgusted with the attempts of WAG to try and brainwash residents. I am sure if you checked you will find these people (WAG) to be less than truthful and very bitter. I have dealt with these people and I am glad NOT to call them friends.

11)I have livestock, no problems.

#106

10)[quality of life altered] I cannot go a day without thinking about Wind Turbines. They are everywhere you look, noisy, lights flashing.

Does the Wind Farm effect our families Health. How long does it take 1year/5 years/10 years.

I do not know exactly how much value our house has lost. 40/50/60 THOUSAND MAYBE?

If you raise a family today, How long does it take to save 60 THOUSAND DOLLARS. I believe we lost that.

One thing that could make matters worse is the idea that my tax Dollars might be subsidizing a Wind Project.

Thanks for your efforts.

#107

10)[quality of life altered] Biggest factor is the noise.

Unable to sleep with windows open at night and I'm a poor sleeper under good conditions. Find when I'm outside gardening or reading the constant noise from the blades turning very irritating and I find I have a pressure in my ears that wasn't there prior to the last few months.

#108

6) [nearest turbine to property] There is at least one on each corner of my home (see map attached)
Nearest is 481.8 meters

9) [other] Digestive problems/ chronic upset stomach

9), 10) and 11) Hello, my name is [home owner] and I had a Dream.

I knew in my early 20's that I wanted to move north and build my dream home. I was born and raised in the City, but undeniably a country boy at heart. I worked with my Father who was a Carpenter by trade for most of my life, and I naturally followed in his footsteps. This gave me the skill set and knowledge required to be able to one day realize my Dream.

It was the late 1990's and me in my early 30's, I was financially ready and began looking for the perfect spot. I would need to be close to the city to commute for work, but far enough to enjoy the Country Living lifestyle that I had been dreaming of for 10+ Years now. My search took me all over Northern Ontario and was a 3 year process.

Finally in 2001...I found it!! A 1 Acre Corner lot Located in the Township of [township]. The next step was to go thru the process of obtaining Building Permits, and designing my home to the Townships approval. For anyone that has gone thru this, they will tell you that it is a lengthy and sometimes frustrating process, but worth the reward in the end (or at least suppose to be). In 2002 I started construction on my outbuilding (barn), and in 2004 my home.

It was 2005 when I first caught a glimpse of phase 1. I was on my way home from work and saw these massive windmills being erected. My first thought was "what the heck is going on here?" and my thoughts after that I can not mention is this letter. I began making inquiries, and came to find out that [township] Township had become the new home of a [wind company] Wind Farm.

I had, and still have a hard time understanding how this could have happened without me knowing. After speaking with the Township and asking this very question, they informed me that the Residents of [township] were indeed notified, unfortunately for me the means of notification were not (in my opinion) appropriate.

The notification process consisted of:

1.) A notice was posted on the Township Website.

**At that time and up until 1 Month ago, I did not have internet access at my home nor own a Computer.

2) Notices were posted in the Local Newspaper.

** I was working full time and building a home on my own, I didn't have time to read the paper.

3) A notice was in the Township Newsletter that comes in the mail with your Property Tax Bill.

** With all the advertisements, flyers, pamphlets, etc...that come in the mail these days, it is hard to keep up. I am sure that many people are like me, they open it up (whatever it may be) take out the bill and recycle the rest.

At no point in time was there ever a notice or letter sent to my home, it was assumed that I would come across one of these methods of notification. I feel that this was very presumptuous of the Township and [wind company], this information SHOULD have been shared with residents via Direct mail, not left to the possibility that one might come across it.

So here I am, not even half way thru building my home and now I have these windmills almost, but not quite, in my backyard. After much soul searching I decide to forge ahead, block out the images and I concentrate on the things that remind me of why I fell in love with this land. Difficult as it is I manage not to lose sight of "My Dream".

In early 2006, comes the news of phase 2... They are not done yet! And this time they will be right in my backyard, front yard and to both sides of my house. I am surrounded.

Now the windmills in phase one have been up and operational for approximately 1 year and residents have had an up close and personal experience. They have quickly come to realize that they are not all they were cracked up to be.

After attending the Township and planning meetings for phase two, there was definitely not a positive reaction to the news of more noise makers moving into Town. Residents managed to put up enough of a fight to halt it for a short period of time, but it is very difficult to fight a Township that wants the Revenue that comes from allowing this type of project, and a Corporation the size of [wind company]. The offer is too good, the Corporation is too strong, and eventually Politics and Money win out over Resident's wishes. A modern day David and Goliath.. The giant(s) win again.

In December 2008 phase two was turned on, since then I have not slept thru the night. I have had to go to the Doctor and have sleeping pills prescribed so that I can get to sleep, but I am inevitably awakened each night.

My quality of life is and has been affected, I no longer look forward to coming home. I get a better night sleep in the city (go figure) and will spend some nights there, but why should I be run out of my home?

Summer is now upon us, I have always looked forward to this time of year. My home was built with summer as the focus, the positioning on my property, location of windows, all designed to enjoy having my windows open all summer long, and use Mother Nature's air conditioning. For this reason I do not have A/C in my home (many people out here don't.. it is (was) not necessary). Now the wind that I look so forward to each summer has become my enemy.

I have become intimately aware of the negative effects involved with living in a wind farm. It's pretty sad that I have to put my T.V on the nature channel and close my windows and doors to hear "Nature" when I live in the middle of the Country!

The more I know, the worse the scenario is. I live in the middle of what sounds like an Airport only worse, at least if I lived next to the airport I would get a break every 30 seconds, and have 'No Fly' times so I could sleep. Between the constant whooshing that echoes thru the skies 24/7, and the humming sound that is omitted from the mechanics of the turbine 24/7, I have gone from being a very easy going, relaxed person to struggling on a daily basis with anything from stress to depression to anxiety. I attempted seeing a massage therapist and chiropractor to help relieve the tension, but this proved to only be a temporary fix, and was quite costly, so I had to stop going. Not to mention the other Health related issues that are now becoming a daily struggle. I have headaches at least every other day; and a constant ringing in my ears; I have had 2 ear infections in the course of a 3 month period, and

occasionally suffer mild hearing loss. I experience digestive problems, and an upset stomach after almost every meal which will last anywhere from a few hours to days. I have gone from being a healthy person that had to visit the doctor once, maybe twice a year (one of these visits being a regular checkup) to having all these symptoms happen at once, and persist for months on end. It is all a little too coincidental, don't you think? Even guests to my home experience similar symptoms when they stay for more than a day.

I lay awake at night and trying to figure out why this has happened. I have come here to realize what has been my dream for over 20 years, and it has turned into what would be a nightmare if I could sleep. Where do I go from here? I am not only financially bound to my home, but emotionally torn. As I consider my options (none of them good) I cry.

The ironic thing about it is I am not even done yet. Just to add a little insult to injury, I have to now finish my dream so that I can walk away from it for the sake of my health.

Why was there not a proper investigation done into Potential Health Risks BEFORE putting these in people's backyards. There is/was so much research available from existing wind farms around the world, none of it was taken into consideration. Had it been, they would not be so close to residences. The required setback in phase one was 400 meters, and was increased to 450 for phase 2. This is crazy, the Provincial Government is now 'Proposing' a setback of 1500 meters from a residence, with a wind farm of this size, and a noise study is required prior to installation. I have a total of 9 turbines surrounding me, on all 4 corners of my property, 1. @ 481.8M 2. @ 563.9 3. @ 576.2 and 4. @ 619.6 and beside #2 is another one @ 700.5. The remaining 4 did not have distance readings available at the Township office, but are not too far from the 5 listed here. Needless to say, I am getting it from every end! I cannot go onto my property any time of the night or day ever again and experience the peaceful serenity, and sounds of nature that made me fall in love with this place, and want to build my dream home here.

My goal with this letter is to bring awareness to the issue that I and many others are dealing with. For those that don't live in the middle of a wind farm, but merely drive thru once in a while, my situation would be hard to understand. It is quite an awe to see for the occasional passer-by, but there is far more to this than meets the eye.

For the land owners that have agreed to have these turbines on their property, I would be curious to know, how much was my Dream worth? Because it is worthless to me now. And what is [wind company] and [township] Township prepared to do?

Thankyou,

[home owner]

#109

6) [how far are turbines] 481.8 meters - Total of 9 surround

9) [other symptoms] -Nausea, Dizzy (occasional) - Digestion

[approached doctor] No, symptoms stop when I return home.

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WindVOiCe (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

10) It is difficult when you want to visit your loved ones, however, you know that you are going to an environment that will cause you harm. Not a choice anyone should have to make!

Essentially, the wind energy industry is forcing people to stay away from their families and loved ones, which is unacceptable!

#110

8) [health affected] yes, (mostly mental health

9) [other symptoms] cannot deal with noise

10)[quality of life altered] –cannot enjoy the outdoors and sounds of nature because of noise

-hesitate to invite friends over

-feel upset that we built our amazing energy efficient ICF home in an area full of horrible noise pollution.

-feel violated

-upset that my lonely elderly mother came to live with us to have a happier life but now has vertigo (we have not mentioned to her the possible correlation to windmills.)

-feel like we should have known better!

-we trusted township and [wind company]

#111

9) [approached doctor] yes, for tinnitus – pending

10)[quality of life] – do not feel desire to improve our house (finish work started)

-do not enjoy outdoor exercise when windy and noise from windmills

#112

9) [other symptoms] vertigo

[approached doctor] yes for vertigo – take medication

-she's never had this before.

10) [life altered] because of vertigo * we are looking after [mother] and do not wish to give her windmill details.

#113 - Young Child-Form completed by parent

9) [headaches, palpitations] too young to describe.

[hearing problems] We are having hearing re-checked. Family Dr. found swelling, excessive wax.

[sleep disturbance] sleeps but does not seem rested.

[approached doctor] Family Dr. [doc's name] suggested hearing test, documented visit, found no issues apparent – does not have knowledge of WTS but has heard some comments from local public health.

11) [life altered] I feel both my children are "different" in their behaviour – two happy, well-behaved children have become irritable and unreasonable w/ tempers and agitation – reminds me of an overtired or hungry child. This is compounded by the fact that my husband and I are affected and sleep deprived and I imagine have lower patience, tolerance and are irritable also. [Child's name] describes "bees" in his ears – I believe ringing ringing from W.T. s.[wind turbines]

#114

Young Child-Form completed by parent

9) [headaches, palpitations] too young to describe.

[stress, anxiety, tinnitus] slaps his head sometimes

[sleep disturbance] sleeps but does not seem rested. Very irritable/ complete change in personality.

[approached doctor] Family Dr.[doc's name] documented visit, found no issues apparent – does not have knowledge of WTS but has heard some comments from local public health – confused by vomiting without cough but said some children with large tonsils and mucus can cause vomiting.

10) [life altered] I feel both my children are "different" in their behaviour – two happy, well-behaved children have become irritable and unreasonable w/ tempers and agitation – reminds me of an overtired or hungry child. This is compounded by the fact that my husband and I are affected and sleep deprived and I imagine have lower patience, tolerance and are irritable also. [child's name] vomits sometimes for no reason – seems to have motion sickness which I think is from wind turbines.

#115

9) [other] Flashing lights (irritation), kept waking up.

#116

9) [approached doctor] Yes, 1) heart tests 2) CT scan – ruled out stroke and or tumours.

10)[life altered] No energy – due to lack of sleep

-depression and irritability

#117

9) [other symptoms] rapid heartbeat, shallow breathing, overall sensation of being pressurized as if I could explode aggravated digestive problems, cannot relax.

10) [life altered] – cannot sell property. Municipal value @\$258,000 – listed @ \$239,000 – nobody has viewed.

- the other night I woke up because of a very loud, insistent pounding in my ears, accompanied by a headache. As I'm waking, I wonder where that noise is coming from. I am ready to holler at my neighbour across the road to turn down her radio. I then realize with concern, that it's me. That noise is my pulse racing, making the same sound the wind turbines make, but much faster. If you can imagine the beat of "Paint it Black" by the Rolling Stones, that would be the speed of my heart beating. It was a pleasant very still night and I was actually having a pleasant dream. The turbines were operating.

- this has happened 4 times that I can remember, once while awake. I find if I change position, the pounding sensation goes away.

- all symptoms are more noticable when I'm laid off (an annual event-longer each year) and in and around my house 24/7.

- I have previously attributed any problems to financial stress. I now believe that stress is being compounded by low-frequency noise.

- I don't want to take any medication in order to sleep, low blood pressure, etc. If there is a physical ailment, I believe in eliminating the source rather than treat the symptoms.

- I just want to move.

- complete lack of energy I have on a daily basis. I feel as if I could sleep all day, every day, with no incentive to do anything at all. It seems like these turbines are draining the energy out of me

11) [pets affected] not apparent.

#118

6) [nearest turbine] [turbine] transformer station

9) [palpitations] vibrations

[sleep disturbance] on most nights

[other] broken sleep, aching muscles

10)[life altered] The transformer station has been operating for over 3 years. We have had endless nights of broken sleep. I wake up tired, seem to be anxious all the time. Everything seems to upset me.

Have asked MOE [Ministry of Environment] for a letter that says there is no problem with the wind farm so we can sell our farm for a reasonable sum but they will not give us one because there is a problem. But when you say fix the problem to MOE they say the transformers are in compliance.

What do we do!

#119

6) [nearest turbine] [turbine] transformer station

10) [life altered] Here is our history. On April 20, 2005 we attended a public meeting at the [township] township hall to hear about the proposed installation of [wind company] transformer station. The

members of the community asked the township council not to pass this installation. Our fears were for noise and health effects with such a an electrical installation so close to our home(490) metres. It was passed anyway.

[wind company] installed the first transformer and energized it on February 23, 2006. We are the adjoining property owners. For the next few days afer that date, we heard a loud, penetrating buzz/hum. We wondered what was the source of the noise. Gradually, we realized that it was the transformer. It seemed to make more noise in the evening and early morning hours. The sound was more extreme with any form of water vapour in the air, either rain, frost, or fog. The noise was heard inside our house with all the doors and windows closed. We found that we could not sleep for more than 30 or 40 minutes at a time, awakening over and over again to the sound of the transformer.

We issued many pleas to council and [wind company] for help, and attended meetings for over a year. We finally appealed to the Ministry of the Environment, and the transformer noise was found to be in excess of the legal limits. Finally they constructed a noise absorbing wall and earthen berm, topped with trees. This helped dim the noise a little, but it was still disturbing. We could not get away from the noise even in the refuge of our own home. We felt pressure on our ears, like an airplane take off. At times the intensity of the noise made my ears hurt and vibrate. We were constantly sleep deprived, exhausted and stressed. I awaken to find myself with the blankets over my head. I believe this is an unconscious action to protect myself from the effects of the noise.

The OMB hearing took place October 2007, and the original [brand] transformer was ordered to be replaced with a supposedly quieter [brand] brand. At this time a second transformer was allowed to be installed, also a [brand] model. During this time period, we co-operated with [company] Engineering to do noise recording testing inside our homes. The MOE abatement officer looked at these reports and concluded that the intrusive noise was in the low frequency range, 360 hz.

The second transformer was energized in February 2009. The noise is still intrusive, but it is now coupled with a penetrating vibration in our home and even in our bodies. It is a terrible feeling. We have reported our distress multiple times to MOE and [wind company] via their noise reporting protocol telephone number. We have co-operated with [wind company] noise consultants [company] Engineering. They have done four season audits, first for one transformer, and now for the two of them. Our distress has not been heard, and their usual answer is "it's in compliance".

All of us here have suffered with many severe headaches, ringing ears, heart palpitations and unending fatigue. With the stress and anxiety we suffer, we can hardly think straight and are irritable and short tempered with each other. Our nerves are frayed. When will there be some relief? Will it ever end? When will we ever get a good night's sleep again?

In an effort to try and help ourselves, we had [name withheld] do an electrical assessment of our house. His graphs showed a great deal of "dirty electricity" coursing through our home. He likened it to living in a microwave. He stated: "This is a bad house, a very bad house." He felt that we were sensitized to the electricity and that was contributing to our health issues.

We contacted Hydro One and they have installed monitors in our home on two different occasions. The first round of tests were inconclusive and we have not received any feedback from the second set.

Our anguish is great. We feel betrayed. There is no help. This is our home, our refuge, but we can hardly stand to be here.

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WindVOce (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

[homeowner's name]

#120 [family collaborative effort #120-124]

9)[headaches] severe

[sleep disturbances] severe

[other] -mouth feels like clenching teeth (but not)

-TOTAL LACK OF CONCENTRATION,

- heavy painful chest, heart pounding

- Weight gain-can't seem to loose the weight

- Your eyes feel like they are being "dug" out of the eye sockets

- takes more medication to do the job, as you do not respond to the medication the way a normal person would....Eg. 2 or 3 rounds of antibiotics to get over a bout of pneumonia, (immune system compromised)

- wear outdoor boots/shoes IN THE HOUSE, to try and help prevent our feet from "burning" hurting

- severe mood swings

- sores and injuries do not heal very well

- tingling in extremities, body aching(a lot),s

[approached doctor] NOTE: the family doctor is so busy with (shortage of doctors) surgery, office, covering emergency at hospital that unless another doctore speaks to him about the facts he appears to not want to acknowledge the symptoms. - heart tests - eye tests - xrays -CAT scans - Blood testing

10) [life altered] - when you don't get a proper sleep, then you can't comprehend everything that is going on and you can't concentrate or remember

-you get chest pains

- you are so tired that you just don't even want to get up and going... Your weight is increasing and you can't seem to get it off

-your ears are constantly ringing and it makes it hard to hear

- NOTE: when we go away from the farm the headaches ease up,

- but to have the effects of the wind turbines ease you need to leave the farm for more than 3 weeks, at least.

11) The cattle became very aggressive at times, a lot more assisted births, abortions, prolapses, reproduction problems (symptoms too numerous to mention)

#121 [family collaborative effort #120-124]

9) [other] –nauseated, mouth feels like clinching teeth(but not)

-go to the washroom more often

-TOTAL LACK OF CONCENTRATION, cant even spell/add right, at times

- Your memory is just not what it used to be

-heavy painful chest, heart pounding

- unusual bloody noses,

- Your eyes feel like they are being “dug” out of the eye sockets

- takes more medication to control symptoms

- can't walk straight (when turbines are powering up/down quickly) equilibrium is off, inside of ear always seems itchy

- wear outdoor boots/shoes IN THE HOUSE, to help prevent our feet from the “burning” hurting feel

- sores and injuries do not heal very well(your itchy/scratching)

- body aching

- there are times(a lot) when I would go to town just to sit to get away from the effects of the turbines (ease the pressure in chest, head and ears)

[approached doctor] Heart tests,

- NOTE: the family doctor is so busy with {shortage of doctors} surgery, office, covering emergency at hospital that unless another doctor speaks to him about the facts he appears to not want to acknowledge the symptoms.

10) [life altered] –when you don't get a proper sleep, you can't concentrate r

-you get chest pains

- when I go near florescent lighting or those new light bulbs I get a severe headache and my eyes feel like they are being pulled out

- your ears are constantly ringing

- NOTE: when we go away from the farm the headaches ease up, but to have the effects of the wind turbines you need to leave the farm for more than 3 weeks, at least, and the longer you are near the wind farm the longer it takes to have the symptoms “start” easing when you leave.

11) [pets and livestock] – The cattle became very aggressive when the wind turbines were putting out the power, and there was a noticeable amount of other problems

- We used to have cats but shortly after the turbines started up they disappeared with the odd stray only staying around for a short period of time.

- You expect to have mice on a farm, but they have even disappeared.

#122 [family collaborative effort #120-124]

9) [other symptoms] – heart pounding

- Lack of memory

- ears itchy and ringing

- bloody noses, ears itchy and ringing

- body joints aching

[approached doctor] General testing – Heart tests (Holter monitor)

10) [life altered] – when you don't get a proper sleep, then you can't comprehend everything that is going on and you can't concentrate or remember,

- extreme mood swings

- at my age, I should not be having chest pains

- severe headache and my eyes feel like they are being pulled out

- your ears are constantly ringing and it makes it hard to hear

NOTE: when we go away from the farm the headaches ease up, but to have the effects of the wind turbines you need to leave the farm for more than 3 weeks, at least.

- the worst thing is: I felt I had to move totally away from this area to try and protect myself from the effects of the wind turbines!

12) [pets and livestock] - no cats – our collie became "clingy", he would always be around humans

#123 [family collaborative effort #120-124]

9) [other symptoms] – irritated and agitated very easily

- mouth feels like clinching teeth (but not)

- TOTAL LACK OF CONCENTRATION

- Weight gain-can't seem to loose the weight
- body aching,
- takes more medicine to keep symptoms under control

[approached doctor] General testing – blood tests – xrays – specialized testing

10) [life altered] – when you don't get a proper sleep,

- you can't concentrate
- your ears are constantly ringing and it makes it hard to hear
- NOTE: when I go away from the farm the headaches ease up
- I trained in Agriculture in Ontario in order to be able to take over with my sisters, the family farm and now there is no farm to take over, as the wind company does NOT appear to be trying to FIX the problem
- the worst thing is: I have had to move totally away from this area to try to protect myself from the effects of the wind turbines.

- if it is doing so much damage to our cattle what is it doing to us as people

11) [pets and livestock] –the cattle became very aggressive at times,

- a lot more assisted births,

#124 [family collaborative effort #120-124]

9) [other symptoms] – nauseated/ stomach upset

- heavy painful chest
- extreme mood swings

[approached doctor] General testing – Gastro-intestinal testing

10) [life altered]- when you don't get a proper sleep- you can't remember stuff, it affects your memory

- irritated and agitated very easily, (extreme mood swings)
- I get a headache and my eyes feel like they are being pulled out.
- NOTE: when we go away from the farm the headaches ease up and go away

- I trained in Agriculture in Alberta in order to be able to work with my sister to take over the family farm and now there is no farm to take over as the wind company does NOT appear to be trying to FIX the problem

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Wind VOCE (Wind Vigilance for Ontario Communities)

A self-reporting survey: adverse health effects with industrial wind turbines and the need for vigilance

March/July/September 2009

- the worst thing is: I have had to move totally away from this area to protect myself from the effects of the wind turbines!

- when I go near florescent lighting or those new light bulbs

11) [pets and livestock] – used to have 20+ cats but shortly after the turines started up they disappeared with the odd stray only staying around for a couple of hours, but they NEVER came back

- big change in the cattle behaviours

- a lot of calving problems

1781

Search

